An Empirical Examination of the Interest Rate Swap Market

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Consistent with Sun, Sundaresan, and Wang's (1993) findings, an empirical investigation of the interest rate swap market shows the presence of a default risk premium in the rates quoted by swap dealers. The bid-offer spreads exhibit a decline since 1987. The spread over the Treasuries and the spread between the swap bid and offer rates are statistically significant for all swap maturities. Term premiums exist in the rates quoted by swap dealers.

INTRODUCTION

Academic research on interest rate swaps has concentrated on the growth of the swap market, the pricing of interest rate swaps, the default risk in interest rate swap contracts, and the regulation of the swap market. Few studies have examined the empirical aspects of the swap market. This study uses the methodology of Sun, Sundaresan, and Wang (1993) to analyze the swap market empirically.[1] To examine the effect of dealers' credit reputations on swap quotations and bid-offer spreads, Sun, Sundaresan, and Wang use daily quotations from two interest rate swap dealers with different credit ratings (A and AAA). They select swaps in which fixed U.S. dollar interest rates for a given maturity are exchanged for a six month London interbank offer rate (LIBOR), the floating rate of interest. Sun, Sundaresan, and Wang find the bid-offer spreads sensitive to the swap dealers' credit reputations. The swap bid/offer rates of an A-rated dealer are bracketed by the rates of an AAA-rated dealer. Moreover, Sun, Sundaresan, and Wang document that the spreads between the swap rates and the Treasury yields generally increase significantly with maturities. Also, the increase in the spreads between the swap rates and the Treasury yields is much smaller when the Treasury yield curve is inverted. To investigate the

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[1] This study examines the robustness of Sun, Sundaresan, and Wang methodology. This study covers a longer time period, uses swap data from a different source, and includes interest rate swaps that involve annual exchange of interest. For a discussion on the significance of replication of previous economic studies, see Kane (1984), Mittelstaedt and Zorn (1984), and Anderson and Dewald (1994).

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implications of default risk in swaps Sun, Sundaresan, and Wang compare the par bond yields of the counterparties with swap bid and offer rates.[2]

This study uses biweekly interest rate swap quotations from *Swaps Monitor* from October 1987 to November 1991 to analyze the behavior of swap rates. These rates are pertinent to interest rate swaps in which fixed U.S. dollar rates are exchanged for the one year LIBOR floating interest rate. The principal goal of this study is to investigate whether the Sun, Sundaresan, and Wang conclusions are valid across a cross-section of the swap market or if these results apply only to the swap dealers used in the original study. Furthermore, this study also investigates if the Sun, Sundaresan, and Wang results can be extended to swaps in which fixed interest rate is exchanged for a one year LIBOR floating rate.

Finally, this study also examines the empirical evidence of the default risk premium in the swap market. Dealers in interest rate swaps act as market makers and readily quote the interest rates at which they will take either side of interest rate swaps with simple structures and standard maturities (typically between two to ten years with semiannual interest payments). By acting as swap dealers, intermediaries assume the counterparties' credit risk and hope to profit from the bid-offer spread. Assuming no transaction costs and no default risk (as argued by Sun, Sundaresan, and Wang), the arbitrage-free fixed swap offer rate on the settlement date should equal the yield on a default-free bond with the same maturity issued by the party making the fixed payments.[3] When there is a default risk, swap pricing theory implies that the yield on a par bond of equivalent maturity is greater than the swap offer (or bid) rate. The yields on a par bond of equivalent maturity are, therefore, either greater than or equal to the swap rate. We examine this issue empirically by comparing par bond yields with the swap rates quoted by swap dealers. In this study we reexamine the validity of the Sun, Sundaresan, and Wang results using biweekly swap quotes instead of the daily swap rate quotations. Further, we extend the results of the Sun, Sundaresan, and Wang to a slightly larger time period. In conducting an analysis of the default risk premium in the swap market we are subject to the same constraints as Sun, Sundaresan, and Wang.[4]

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[2] To estimate par bond yields in the interbank market, Sun, Sundaresan, and Wang use the LIBOR and LIBID from the interbank market. The swap and interbank markets, however, differ in liquidity. Therefore, Sun, Sundaresan, and Wang examine the extent to which the par bond yields estimated from the interbank market fluctuate with the change in swap quotes by regressing changes in the par bond yields with the changes in swap quotes. There is a low degree of correlation between the daily changes in swap rates and the daily changes in LIBOR par bond yields. Sun, Sundaresan, and Wang also find that regressions based on weekly changes in swap rates and par bond yields perform better than daily changes. This may be due to the fact that LIBOR data do not correspond to rates at which actual transactions occur. Therefore, their results regarding the tracking of swap offer rates with par bond yields constructed from LIBOR must be interpreted with caution. They also suggest that actual transactions data are critical in examining the implications of swap pricing theory.

[3] It also suggests that, assuming no transaction costs and no default risk, the fixed swap bid rate should equal the yield on a par bond of equivalent maturity issued by the swap dealer.

[4] To estimate the par bond yields in the interbank market this study estimates LIBOR and LIBID from Eurodollar time deposit rates. The swap market and the interbank market differ in liquidity. Therefore, the conclusions regarding default risk premium in swap rate quotations should be viewed within the framework of this constraint.

PREVIOUS STUDIES

Studies conducted in the initial stages of growth of the swap market explored the uses, risks, and regulatory aspects of swaps and the rationale for the growth of the swap market.[5] A number of studies address the issue of default risk and its incorporation in the price of an interest rate swap contract. Whittaker (1987) uses an option pricing framework to address the problem of credit risk and its role in the pricing of an interest rate swap contract. Cooper and Mello (1991) analyze credit risk in an interest rate swap contract in a partial equilibrium framework. They model a swap contract as an exchange of a fixed rate debt for a floating rate debt. Abken (1991) models swaps as a combination of caps and floors with the same strike price. He analyzes default risk in a partial equilibrium framework. Brown and Smith (1993) discuss innovations in the design of interest rate swaps to deal with the problem of default risk in interest rate swaps. They consider two innovations to swap design: mark-to-market swaps and forward rate swaps. According to them, the mark-to-market scheme reduces the default-risk effectively in comparison to a forward rate swap scheme.

Giberti, Mentini, and Scabellone (1993) outline standardized valuation criteria proposed by regulatory authorities and develop a methodology that can be used to quantify the effective credit exposures of various types of currency and interest rate swaps and to estimate potential credit exposure from off-balance-sheet operations.

In recent years studies have focused on empirical aspects of interest rate swaps. McNulty's (1990) empirical investigation into the pricing and the credit risk aspects of interest rate swaps reveals little evidence of credit risk premium in the swap market. Using an autoregressive process Brooks and Malhotra (1994) show that the swap market does consider default risk while quoting bid-offer rates.

THEORETICAL FOUNDATION

An interest rate swap is an agreement between two parties (counterparties) to exchange a series of interest payments over a period of time without exchanging the underlying principal amount. These payments are tied to different indexes, such as LIBOR, the Treasury rate, or some other index. The underlying principal amount in a swap contract is called the *notional principal*. For instance, in a fixed-for-floating interest rate swap contract one party pays the other party a fixed interest rate on the notional principal amount at specific intervals. Similarly, the second party pays the first, in return, the six month LIBOR on the notional principal.

The party paying a fixed interest rate and receiving a floating interest rate is short a fixed rate bond and long a floating rate bond. On each settlement date the difference between the fixed and floating interest rate is exchanged by the parties. When we model a swap as an exchange of a fixed rate bond for a floating rate bond the fixed rate on a swap should equal the yield on a par bond, assuming that there are no transaction costs and no taxes. This also assumes that there is no risk of default in a swap contract and no arbitrage possibilities. If the yield on the par bond is less than the all-in swap fixed rate, arbi-

[5] Bicksler and Chen (1986), Smith, Smithson, and Wakeman (1986), Turnbull (1987), and Wall and Pringle (1988) analyze the rapid growth of the swap market since early 1980s. Studies by Whittaker (1986), Felgran (1988), and Wall, Pringle, and McNulty (1990) cover regulatory aspects of the swap market.

trage is possible. In a swap contract in which the market maker is paying a floating interest rate and receiving a fixed interest rate, arbitrage opportunities exist by shorting a fixed rate bond with a principal amount equal to the notional principal amount of the swap contract and investing the same amount in LIBOR maturing on the next settlement date.

In the presence of default risk a swap contract is an exchange of a default-risky fixed rate bond for a default-risky floating rate bond. There are some inherent differences between the risk of default in a swap contract and the risk of loss due to default on a loan. In the case of a loan only the party long on the loan is subject to default risk, while in a swap contract both parties are exposed to default risk. Second, in a swap contract the risk of loss due to default is lower because the net exchange is the difference between the fixed interest rate and the floating interest rate on the settlement date multiplied by the notional principal. Moreover, swap contracts also carry a provision whereby a party to the swap is relieved of its obligations under the swap contract if the counterparty defaults. Thus, the impact of default risk on a swap contract is less than its impact on a loan.

As swap houses, market makers serve as intermediaries in the swap contract and assume the credit risk of the counterparties to the swap contract to guarantee performance. They profit from the bid-offer spread that is reflected in the all-in swap bid and offer rates quoted by them less administrative costs and credit losses. As argued by Sun, Sundaresan, and Wang (1993), however, the bid-offer rates in the swap market are narrower than those of the interbank market, reflecting low transaction costs in the swap market. Therefore, the par bond yield of counterparties should be higher than the swap offer rate to reflect higher transaction costs and higher default risk. Thus, our null hypothesis is that the par bond yields equal the swap rate and default risk is not taken into account by the swap dealers while quoting bid-offer rates. The alternate hypothesis is that the par bond yields exceed the swap rates and default risk is taken into consideration by the swap market.

DATA DESCRIPTION AND ANALYSIS

This study conducts an empirical analysis of the data available from the various issues of *Swaps Monitor*.[6] The data are biweekly from October 1, 1987 to November 2, 1991 for a swap with a maturity of two, three, four, five, seven, and ten years. The data set includes information on the all-in swap bid-offer rates, the Treasury rate of equivalent maturity, and the maturity of the swap contract. These rates apply to interest rate swaps in which fixed U.S. dollar rates are exchanged for the one year LIBOR floating rate of interest.[7] The data set also includes the bid-offer information for Eurodollar time deposits. Eurodollar time deposit bid-offer rates are available for a maturity of two, three, four, and five years only.

An initial examination of the Treasury yield data indicates two distinctly different sample subperiods. From October 1987 to December 1988 the yield curve is upward sloping. The yield curve is inverted from December 22, 1988 to October 26, 1989 (a total of

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[6] *Swaps Monitor* is a biweekly publication of Swaps Monitor, New York, NY 10276. Data are based on quotations provided by *Tullet and Tokyo Forex*.

[7] In the empirical analysis we incorporate the difference between the money market and the bond yield conventions. In an interest rate swap where the one year LIBOR is exchanged for a fixed rate every year the fixed rate payments typically follow bond yield convention, whereas the LIBOR payments are subject to the money market convention. Thus, we have to compare the swap rate with adjusted LIBOR par bond yield, which equals coupon × (365/360).

Figure 1—Treasury Yield Curve, Biweekly Data

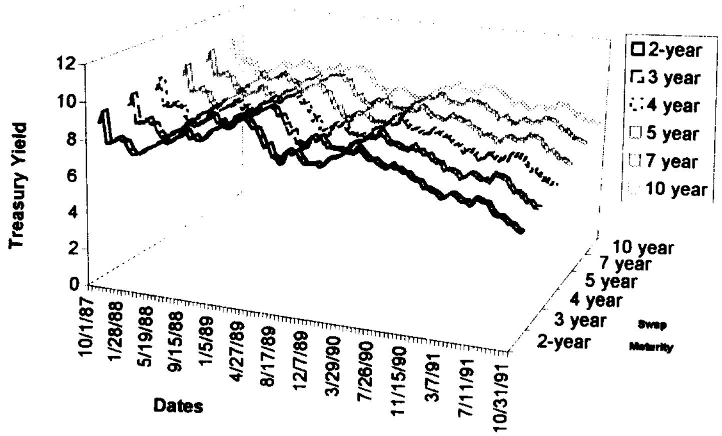


Figure 2—All-In Swap Offer Rate, Biweekly Data

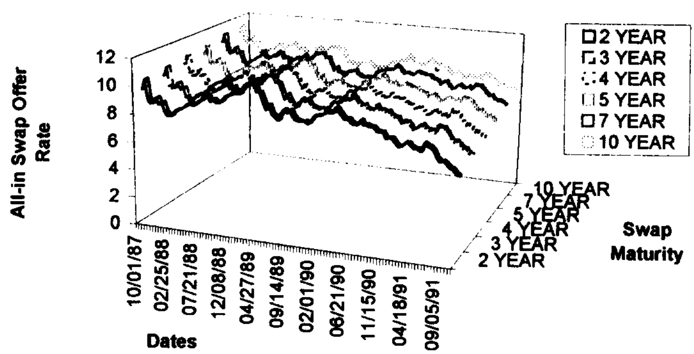
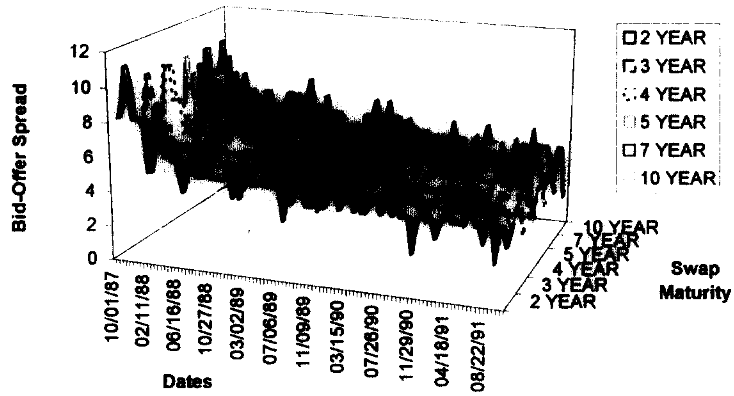


Figure 3—Bid-Offer Spread in Interest Rate Swaps, Biweekly Data



22 observations).[8] Figure 1 displays the surface of the Treasury yields with a maturity of two, three, four, five, seven, and ten years. The all-in swap rates replicate the behavior of the yield curve. Figure 2 illustrates the behavior of the all-in swap offer rates.

Swap rates are rising with the normal yield curve; while with an inverted yield curve swap rates decline. This can be attributed to the convention of quoting all-in swap rates as an add-on to the Treasury yield for an equivalent maturity. For the overall sample the average Treasury yield increases from 7.90 percent for a maturity of two years to 8.51 percent for a maturity of ten years. The average all-in swap offer rate increases from 8.54 percent for a two year maturity swap contract to 9.33 percent for a ten year maturity swap contract.

For the overall sample the bid-offer spread declines with an inversion of the yield curve. Figure 3 illustrates the bid-offer spread in the swap market since October 1987 for different swap maturities.

The average spread between the bid and offer rates varies between 5.06 and 5.34 in basis points for different swap maturities for the overall sample. For the inverted yield curve sample, however, the average spread between the bid and offer rates varies between 4.61 and 5.30 for different swap maturities.

[8] This study divides the sample depending on the shape of the yield curve because the swap market activity is influenced by the interest rate expectations and consequent desired interest rate exposure of the participants.

Table 1—Spread Between Swap Offer Rates and Term Treasuries (in basis points) October 1987 to November 1991

	Maturity of the Swap Contract					
Statistics	Two Year	Three Year	Four Year	Five Year	Seven Year	Ten Year
Full Sample Period (N = 106)						
Mean	58.7	67.0	69.3	71.8	72.3	75.8
Standard Deviation	15.6	14.4	12.1	13.5	13.5	13.7
t^2	38.7	47.6	58.6	54.3	54.8	56.7
Inverted Yield Curve Sample Period (N = 22)						
Mean	65.4	65.8	68.8	72.3	72.5	76.4
Standard Deviation	12.5	7.6	7.1	8.8	9.1	8.2
t^2	24.6	40.8	45.2	38.5	37.5	43.8

t-statistics show the results of univariate analysis. The following methodology is used to calculate t-statistics: $\{\mu/[\sigma^2/n]^{1/2}\}$. Where μ is the mean of the sample, σ represents the standard deviation, and n is the number of observations in the sample. t-statistics are significant at a 1 percent rejection level for both the full sample period and the inverted yield curve sample period

Table 1 summarizes the characteristics of the spread between the Treasuries and the all-in swap offer rates from October 1987 to November 1991. A univariate analysis suggests that the spreads are significantly different from zero for all swap maturities, implying the presence of high transaction costs in the swap market. Another factor that can explain the statistically significant swap spreads over the Treasuries is the hedging costs faced by the swap dealers. A swap dealer generally hedges the interest rate risk on a swap using U.S. Treasury and government repurchase markets before matching the position with an offsetting swap. Swap spreads tend to rise in order to compensate for the higher financing costs incurred by the dealer.

We also analyze the spread between the Treasuries and the all-in swap bid and offer rates from December 22, 1988 to October 26, 1989 when the yield curve is inverted. These spreads are also significantly different from zero.

Table 1 shows that the spread between the all-in swap rates and the Treasury yields increases with an extension in the maturity of the swap contract. The increase is much smaller when the yield curve is inverted. The overall direction and shape of the Treasury yield curve affects swap spreads to the extent that they influence interest rate expectations and, therefore, the desired mix of interest rate exposure. If interest rates are expected to fall, borrowers would not prefer a fixed rate of interest because they would not want to bear the risk of locking in interest payments at a high rate should interest rates fall in the future. Thus, the supply of fixed rate payers would decline, driving swap spreads lower. This explains the decline in the spreads during the inverted yield curve sample period. Similarly, if interest rates are expected to rise or the yield curve were expected to become steeper, borrowers would prefer to be fixed rate payers, locking in the relatively low interest cost. This pushes up the spreads in the swap market, thus widening the spreads during rallies in the Treasuries market.

Swap spreads at maturities under three years exhibit more volatility than do longer-term spreads. Short-term swaps are priced closely in relation to the implied yield on a strip of Eurodollar futures contracts, which trade in liquid, highly volatile markets. Consequently, the volatility is higher in the short-term swaps market. Longer-dated swaps, on

Table 2—Spread Between Swap Bid and Offer Rates October 1987 to November 1991 in Basis Points

Statistics	Two Year	Three Year	Four Year	Five Year	Seven Year	Ten Year
	Maturity of the Swap Contract					
Full Sample Period (N = 106)						
Mean	5.09	5.12	5.06	5.08	5.27	5.34
Standard Deviation	1.51	1.20	1.37	1.17	1.30	1.37
t^2	34.64	43.84	37.93	44.62	41.54	40.25
Inverted Yield Curve Sample Period (N = 22)						
Mean	4.96	5.17	4.61	4.96	5.30	5.13
Standard Deviation	0.86	0.76	0.97	0.69	0.86	1.12
t^2	27.08	31.91	22.37	33.68	29.05	21.58

t-statistics show the results of univariate analysis. The following methodology is used to calculate t-statistics: $\{\mu/[\sigma^2/n]^{1/2}\}$. Where μ is the mean of the sample, σ represents the standard deviation, and n is the number of observations in the sample. t-statistics are significant at a 1 percent rejection level for both the full sample period and the inverted yield curve sample period

Table 3—Term Premiums of Spreads Between Swap Offer Rates and Treasury Yields October 1987 to November 1991

Statistics	Two Year	Three Year	Four Year	Five Year	Seven Year	Ten Year
	Maturity of the Swap Contract					
Full Sample Period (N = 106)						
Mean		8.29	10.58	13.03	13.61	17.08
Standard Deviation		12.27	10.03	12.17	12.35	13.91
t^2		6.92*	10.82*	10.98*	11.29*	12.59*
T^2 ($F_{5,101}$)		68.74 (16.43)				
Inverted Yield Curve Sample Period (N = 22)						
Mean		0.38	3.34	6.90	7.09	10.92
Standard Deviation		7.50	12.00	14.34	15.02	15.47
^{2}		0.24	1.31	2.26	2.21	3.31*
^{2} ($F_{5,17}$)		0.53 (13.72)				

statistics show the results of univariate analysis. The following methodology is used to calculate t-statistics: $\mu/[\sigma^2/n]^{1/2}\}$. Where μ is the mean of the sample, σ represents the standard deviation, and n is the number of bservations in the sample. t-statistics are significant at a 1 percent rejection level. Term premiums are in asis points. Term premium of spread is the difference between the spread and the two year spread

the other hand, are priced relative to a variety of fixed income spreads that tend to be more stable.

Table 2 shows the summary statistics of the spread between the swap bid and offer rates. The spread between the bid and offer rates is significantly different from zero for all swap maturities for the whole sample period and for the inverted yield curve period. It is significantly higher for a swap with a seven and a ten year maturity, reflecting less liquidity at the higher maturity spectrum of the swap market.

Table 3 illustrates the term premium of swap spreads for different maturities. Term premiums represent the difference between the swap spreads over the Treasuries and the corresponding spread for the two year maturity swap.[9] We use Hotelling's T^2 to test the hypothesis that all term premiums are zero.

Table 3 also shows that the term premiums are significantly different from zero for all maturities for the overall sample. Thus, we reject the joint hypothesis that the term premiums for the overall sample period for all maturities are the same. For the inverted yield curve sample period the term premiums are small and are not statistically different from zero most of the time. We accept the joint hypothesis that the term premiums for the inverted yield curve sample period for all maturities are the same. During the inverted yield curve sample period when the swap market activity is low, the term premiums in the swap rate quotations are not high.[10]

EMPIRICAL ANALYSIS OF DEFAULT RISK

To conduct an empirical analysis of the default risk in the swap market we need to compare the swap bid and offer rates with the par bond yields of equivalent maturity. Specifically, we examine the following hypotheses:

H_0 = Par bond yields equal swap rates;
H_1 = Par bond yields exceed swap rates.

We use Eurodollar time deposit rates to calculate par bond yields because par bond yields of counterparties in a swap contract are not available. Eurodollar time deposits represent dollar-denominated deposits held in a bank outside the United States. The maturity of a Eurodollar time deposit can range from one day to several years. They are money market instruments and follow the conventions of money markets in settlements. We have data for Eurodollar time deposits with maturities of two, three, four, and five years only. Table 4 compares the par bond yields with the swap rates.

Panel A of Table 4 compares the par bond yield, constructed on the basis of the Eurodollar time deposit offer rate, with the swap offer rate. The difference between the par bond yield (constructed on the basis of LIBOR) and the swap offer rate is positive and statistically significant for all maturities. The difference between the par bond yield and the all-in swap offer rates ranges from 6.57 basis points to 9.99 basis points. Panel B of Table 4 compares the par bond yield (constructed on the basis of Eurodollar time deposit bid rates) and the swap bid rate. The par bond yield based on LIBID (London interbank bid rate) is higher than the swap bid rate for all maturities, and the difference is statistically significant. The default risk premium on this side of the swap ranges from 15.61 basis points to 17.77 basis points. We reject the null hypothesis that equates the par bond yields to the swap rates. Thus, the swap market appears to incorporate some default risk premium while quoting the swap rates.

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[9] For example, suppose the swap offer rate for a two year maturity swap equals 25 basis points over Treasuries, while the swap offer rate for a seven year maturity swap equals 35 basis points over Treasuries. The term premium equals 10 basis points (35 bp - 25 bp).

[10] The swap market activity was low during the inverted yield curve sample period because of a slowdown in real estate lending in particular and in bank lending in general because the floating rate liabilities that normally are swapped to fixed rate were not being created.

Table 4—Par Bond Yields Over Swap Rates October 1987 to November 1991

Statistics	Maturity of the Swap Contract Two Year	Three Year	Four Year	Five Year
Panel A: LIBOR - Swap Offer Rate				
Mean	8.41	6.57	8.65	9.99
Standard Deviation	19.89	16.09	12.96	15.00
t^2	4.38	4.23	6.91	6.89
Panel B: LIBID - Swap Bid Rate				
Mean	17.07	15.61	16.76	17.77
Standard Deviation	17.02	13.03	13.21	15.07
t^2	10.37	12.39	13.12	12.20

t-statistics show the results of univariate analysis. The following methodology is used to calculate t-statistics: $\{\mu/[\sigma^2/n]^{1/2}\}$; Where μ is the mean of the sample, σ represents the standard deviation, and n is the number of observations in the sample. t-statistics are significant at the 1 percent rejection level.

SUMMARY AND CONCLUSIONS

Using biweekly swap quotes (October 1987-November 1991) this study reexamines the behavior of swap rates. To investigate the presence of the default risk premium in the swap quotes this study compares the par bond yields of counterparties with the swap offer rate of the swap dealer and par bond yield of the swap dealer with the swap bid rate of the swap dealer. Consistent with Sun, Sundaresan, and Wang's study (1993), this study confirms the presence of the default risk premium in the swap rates quoted by swap dealers. Spreads between swap rates and Treasury yields generally increase with an extension in the maturity of the swap contract, indicating the presence of term premiums in swap quotes.

The spreads over the Treasuries are statistically different from zero for all swap maturities. Moreover, the spreads follow the behavior of the yield curve. During rising yield curve periods borrowers prefer to be fixed rate payers, locking in a low interest cost. This increased demand for swap contracts pushes the spread during rising yield curve periods. During inverted yield curve periods, however, the spread over the Treasury also declines. Thus, the Sun, Sundaresan, and Wang results hold across a cross-section of the swap market and are not restricted to the specific swap dealers used in their study. The Sun, Sundaresan, and Wang conclusions are also valid for swaps in which fixed U.S. dollar interest rate is exchanged for a one year LIBOR floating interest rate.

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