

# The International Linkage of Interest Rate Swap Spreads: The Yen-Dollar Markets

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# The International Linkage of Interest Rate Swap Spreads: The Yen-Dollar Markets

## Abstract:

In this paper, we investigate Japanese yen and U.S. dollar interest rate swap markets during the period 1990-99. We measure the spreads of the swap rates over comparable treasury yields (on Japanese Government Bonds (JGBs) and U.S. Treasury bonds, respectively) for different maturities. We then analyze the relationship between the swap spreads in the two markets.

Our main empirical results are that:(1) the correlations between yen and dollar interest swap spreads are low, indicating that the credit risk factor is country-specific, rather than global in nature, (2) dollar interest rate swaps “Granger-cause” the changes in the spreads of yen interest rate swaps for the long (ten-year) maturities, but the causality does not run the other way, and (3) yen swap spreads are highly correlated with the interest rate differentials between the two markets, and the interest rate differentials have a significant impact on subsequent movements in the yen swap spreads. These empirical results indicate that the specific institutional aspects of the yen fixed income market, such as illiquidity and market frictions, may have affected the yen interest swap rate and the swap spread.

## 1 Introduction

One of the important innovations in financial markets in recent years has been the development of the interest rate swap markets. Recent estimates indicate that the notional outstanding amount of privately negotiated (over-the-counter) derivatives at the end of 1998 was over \$80 trillion, of which interest rate swaps accounted for over \$50 trillion. Given the importance of the yen in international trade and finance, it is not surprising that yen interest rate swaps form a substantial proportion of this amount (about \$10 trillion), second only to dollar-denominated swaps (about \$14 trillion).<sup>1</sup>

Swaps are typically negotiated as zero-value transactions when they are initiated, with the swap rate being defined as the fixed rate to be exchanged for a floating rate such as LIBOR. In the absence of credit or liquidity risks, standard (“plain vanilla”) interest rate swaps can be thought of as the exchange of a fixed rate bond for a floating rate bond. Credit risk adds an important dimension, however, to the pricing of over-the-counter derivative instruments. The important characteristic of over-the-counter (OTC) derivatives, that distinguishes them from exchange-traded products, is that they are not backed by the guarantee of a clearing corporation or exchange. Hence, each of the two counterparties to an OTC transaction is exposed to the default risk of the other. This default risk is particularly important for long-dated instruments such as interest rate swaps.

The main issue we examine in this paper is the inter-market relationship of credit risk between two of the world’s largest swap markets. Given the phenomenal growth in the global swap markets, we would expect the yen and dollar interest rate swap markets to be well integrated in terms of credit risk. If these two markets are integrated, credit risk shocks in one market can be quickly transmitted to the other market and credit risk should be, therefore, a global factor. For instance, during November 1997, the Japanese financial system underwent serious credit problems due to the failures of major financial institutions such as Sanyo Securities, Hokkaido Takushoku Bank, Yamaichi Securities and Tokyo City Bank. Prior to 1997, there was a widespread perception that the Japanese economy had very little systemic credit risk. This could be ascribed partly to the fact that defaults by large companies were extremely rare, and partly to the security blanket offered by the main banks, and ultimately, the central bank. Thus, from the perspective of regulators and market participants, it would be interesting to see if the turmoil in the Japanese financial system was transmitted to the U.S. dollar market, i.e., if the two markets are well integrated.

Specifically, the purpose of this paper is to examine the contemporaneous and causal relationship between yen and dollar interest swap spreads, using the weekly data from February 1990 to December 1999. Using the par bond yields of government bonds in both markets as the basis for comparison, we use the spreads of the swap rates over comparable government bonds, for different maturities, as measures of credit risk in the swap market during the period of our investigation. Existing theoretical models for the pricing of swaps show

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<sup>1</sup>Source: Bank for International Settlements.

that interest rate swap spreads should reflect the counterparty credit risk. Furthermore, several empirical studies offer positive evidence that interest rate swap spreads do reflect the credit risk of counterparties.<sup>2</sup> Thus, we use interest swap spreads as proxies for credit risk to analyze the correlation and lead-lag structure between these markets.

Furthermore, we also analyze the relationship between the yen and dollar interest swap spreads and the interest rate differentials between the two markets. The motivation for the analysis is to examine the impact of arbitrage and relative value trading activity between the two markets. During the past decade, Japanese yen interest rates have been extremely low by historical standards. The low level of yen interest rates makes a spread position between the Treasury bonds in the two countries attractive to arbitrageurs. For instance, arbitrageurs could go long yen interest rate swaps and go short dollar interest rate swaps to construct a synthetic spread position between the Treasury bonds (usually in the respective futures contracts) in the two countries.

A well-publicized recent example serves to illustrate the widespread use of relative value trades between the swap spreads in different currencies. In the mid-nineties, Long Term Capital Management (LTCM), a leading hedge fund, put on several relative value trades between major European currencies. During 1995-96, betting on convergence between the Italian Lira and the Deutsche Mark, LTCM bought the Lira swap spread and sold the Mark swap spread. When Italy met the criteria for the Euro, the trade became very profitable. However, when this strategy was extended in 1997-98 to other currencies such as the British Pound versus the Deutsche Mark, the spread went against LTCM, and the fund lost money. These and other losses threatened the solvency of LTCM and, eventually, given the dominant position of the fund in global markets, the integrity of global markets. However, swap spreads were, and continue to be, a motivation for relative value trades between major currencies.

We study the efficacy of such transactions by examining the relationship between the yen and dollar swap spreads. Specifically, to test if swap spreads are affected by swap market-specific supply and demand factors, we perform “Granger-causality” tests, using the lead-lag relationship between swap spreads and interest differentials between the two currencies.

Section 2 of the paper surveys the literature on the determinants of interest swap spreads. Section 3 describes the main hypotheses and the test methodology on the inter-market relationship between yen and dollar interest swap markets. Section 4 lists the data sources and provides summary statistics for interest swap rates and spreads. Correlation estimates of the swap spreads and empirical results of causality tests are also presented in this section. Section 5 concludes the paper and suggests issues for future research.

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<sup>2</sup>However, there is some weak empirical evidence that swap spreads may reflect other factors such as liquidity and market frictions such as short-sales restrictions.

## 2 Interest Rate Swap Spreads: The Previous Literature

In the absence of factors such as default risk, tax and liquidity effects, and market frictions, a standard interest rate swap can be thought of as the exchange of a fixed rate bond for a floating rate bond. Pricing a swap in this simple setting is fairly straightforward. Since the floating rate bond on the reset date is valued at par when there is no risk of default, the mark-to-market value of an existing swap on a reset date is simply the difference between par and the present value of the cash flows on the fixed side. On a date between resets, the floating side will include the payment based on the last reset. The market swap rate is then defined as the rate that sets the mark-to-market value of the swap to zero, which would be the same as the yield on a par (fixed-rate) bond of the same maturity. In this simple setting, in the absence of credit risk and market frictions, the interest rate swap spread, defined as the difference between the swap rate and a comparable default-free rate, should be equal to zero.

If there is some risk of default, an important determinant of interest rate swap spreads is the credit quality of the counterparty, since interest rate swap spreads should reflect the risk of default. Theoretically, there are two broad approaches to the problem of valuing swaps in the presence of default risk. The first is the “structural” approach first proposed by Merton (1974) in the context of risky zero-coupon debt. In this case, the limited liability aspect of equity is modeled as an option on the firm’s assets.<sup>3</sup> The other approach uses the “reduced-form” of the underlying structure and does not directly deal with the capital structure. Under the “reduced-form” approach, the price of a risky zero-coupon bond can be modeled in an arbitrage-free framework, based on the short-term risk-adjusted interest rate process for defaultable assets such as swaps.<sup>4</sup>

The other important determinant of swap spreads is the liquidity of the swap market relative to the government securities market. Grinblatt (1995) argues that the spreads are partly “a compensation for a liquidity-based convenience yield associated with Treasury notes. This convenience yield is lost to an investor wishing to receive fixed rate payments, who in lieu of purchasing a Treasury note, enters into a swap to receive fixed payments.” In the context of the Vasicek (1977) one-factor interest rate term structure model, Grinblatt shows that many realistic swap-spread term structures can be replicated with liquidity as a state variable.

Despite numerous theoretical models on the pricing of swaps, the empirical work on the behavior and determinants of interest rate swap spreads is rather sparse. Much of the

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<sup>3</sup>Cooper and Mello (1991), Hull and White (1992), Nielsen, Saá-Requéjo and Santa-Clara (1993), Longstaff and Schwartz (1995) and Li (1998) use the structural approach to derive explicit values for derivative securities such as swaps.

<sup>4</sup>This is modeled, among others, by Duffie and Huang (1996), Duffie and Singleton (1997), Jarrow and Turnbull [(1996) and (1997)] and Huge and Lando (2000).

literature tests whether swap rates reflect the default risk of counterparty in the U.S. dollar interest rate swaps. For example, Koticha (1993) postulates a negative relationship between the slope of the term structure and the spread between the swap rate and the yield on a Treasury bond of comparable maturity. He then tests empirically the relationship between the slope of the term structure and the swap rates, using data from five currencies, the U.S. dollar, the Japanese yen, the British pound, the Deutsche mark and the French Franc. The underlying reasoning behind his argument is the “optionality” of counterparty credit risk. For instance, in an upward (downward)-sloping term structure environment, the fixed (floating) rate payer bears more default risk, since, in the early years, she pays more than she receives; hence, she demands a lower (higher) risk premium through a lower (fixed) rate. By regressing the swap spreads on the slope of the term structure and a credit risk proxy, Koticha finds that the coefficient of the slope term is negative and significant. His empirical results indicate that interest rate swap spreads reflect counterparty credit risk.

Sun, Sundaresan and Wang (1993) also test whether the swap rates reflect the credit quality of swap dealers. Using quoted bids and offers from two swap dealers with different credit ratings for their long-term debt (AAA and A respectively), they show that the bid-offer spread for the higher-rated dealer is larger than for the lower-rated one, in the U.S. dollar swap market. Mozumdar (1996) uses a non-linear specification for swap pricing, and estimates a parameter that proxies for the fraction of the promised cash flows that are not received in the event of default. Using two alternative sets of data from dollar and DM swaps during the period 1990 to 1996, he shows that the default risk parameter is positive and statistically significant in the case of dollar swaps. In a recent study on U.S. dollar interest rate swaps, Minton (1997) also finds that swap rates are positively related to short-term interest rate volatility and suggests that the option to default is priced in the swap market. In the case of yen swaps, Eom, Subrahmanyam and Uno (1998) find that yen swap spreads are sensitive to credit risk in the Japanese market. Using the yen swap spreads relative to estimated par bond yields from ten-year Japanese Government bonds during the period 1990 to 1996, they show that the yen swap spread is positively related to corporate bonds yields, negatively related to the level and slope of the term structure, and positively related to the curvature of the term structure. These results indicate that the credit “optionality” is priced into the yen swap rate.

While the studies mentioned above show that interest rate swap spreads reflect the credit risk of counterparties, there is also some empirical evidence that swap spreads reflect other factors such as market liquidity and other frictions. Brown, Harlow and Smith (1994) test for the factors influencing swap rates in the context of a pure expectations model. They find that four variables explain the variation in the swap rates, though less than fully: the spread between Treasury zero-coupon versus coupon bonds (a proxy for the slope of the term structure), the expectation of the TED spread (a measure of the expected credit risk), the overnight bond repurchase (“repo”) rate (an index of hedging costs) and the volume of new issues of corporate bonds (a measure of the hedging demand). Duffie and Singleton (1997) also empirically investigate the relative importance of liquidity and credit factors, using a multivariate vector autoregression (VAR) of the spreads. They find that both factors affect

the temporal behavior of the spreads, but with very different time paths - the impact of liquidity factors is more short-lived. They conclude, however, that a substantial proportion of the variation in the swap spreads is left unexplained, so that further analysis of swap market activity is required to better understand the swap spreads.

### **3 Credit Risk and the Inter-market Linkage of Swap Spreads**

The empirical issue we examine in this paper is whether yen and dollar interest rate swaps markets are well integrated in terms of credit risk. Given the increasing globalization of trade and finance, we would expect that international capital markets are fully integrated. Thus, if swap spreads mainly reflect the counterparty credit risk and/or the default risk of large corporate issuers with global operations, the credit risk should be, at least to some extent, a global factor. As discussed in the previous section, theory and empirical evidence imply that interest rate swap spreads should be determined by credit risk in the swap market. Thus, if swap spreads in yen and dollars are determined by credit risk, we would expect that both swap spreads should be highly correlated.

Although the contemporaneous relationship between yen and dollar swap spreads is important in characterizing the integration of swap markets, the lead-lag relationship between these spreads is essential to the assessment of market efficiency. Several studies examine the causal relationship between interest rate changes in the U.S. and the Eurodollar markets. For instance, Fung and Isberg (1992) employ an error-correction model to test the relationship between interest rates in the domestic and external markets. Their empirical results indicate that there was uni-directional causality leading from the domestic to external markets in earlier periods. More recently, however, they find that there is a significant reverse causality, which may be due to the increased size of the Eurodollar market and the presence of enhanced arbitrage opportunities in the swap and futures markets.

Grinblatt and Jegadeesh (1996) investigate the timing of the flow of information across the Eurodollar forward and futures markets. They find that there is a two or three week delay in the information flow from the futures market to the forward market. However, they find no evidence that there are delays in the flow of information from the forward market to the futures market. Gupta and Subrahmanyam (2000) also examine whether timing differences in information flows between swap market and Eurocurrency futures market explain the differential between market swap rates and swap rates implied by Eurocurrency futures prices. If changes in one rate can predict future changes in the other rate, then the information relevant for future interest rates is not being incorporated into the swap and futures markets simultaneously. Specifically, they test whether the market swap rates predict the implied swap rate from the Eurocurrency futures contracts using lagged daily changes in market swap rates. Although they do find some evidence of predictability in futures rates,

the overall empirical results indicate that the predictability is economically insignificant. They also test the predictability of market swap rates from implied swap rates using lagged daily changes in implied swap rates, and find that there are virtually no delays in the flow of information from the futures market to the swap market.

In this paper, we examine the causal relationship between swap spreads and the differential between dollar and yen interest rates. During the past decade, Japanese yen interest rates have been extremely low by historical standards. The low level of yen interest rates makes a spread position between the Treasury bonds in the two countries attractive to arbitrageurs. For instance, arbitrageurs go long yen interest rate swaps and go short dollar interest rate swaps to construct a synthetic spread position between the Treasury bonds (usually in the respective futures contracts) in the two countries. Such a spread is constructed to take advantage of the differential between the low long-term yields of JGBs and the high long-term yields of U.S. Treasury bonds. Hence, the yen swap rate is upward-biased due to the demand for “pay-fixed” yen swaps.

To examine the causal relationships, we perform a “Granger-causality” test. Specifically, we assume a particular autoregressive lag of length  $p$  and estimate the following equation (1) by ordinary least squares:

$$y_t = \alpha_0 + \sum_{i=1}^p \beta_i x_{t-i} + \sum_{i=1}^p \alpha_i y_{t-i} + \epsilon_t \tag{1}$$

where  $y$  is the dependent variable on which the causality of the variable  $x$  is being tested, with coefficients  $\alpha$  and  $\beta$ , driving the lagged values. The subscripts stand for the date with appropriate lags.

We then conduct an  $F$ -test of the null hypothesis:

$$H_0 : \beta_1 = \beta_2 = \dots = \beta_p = 0$$

If the null hypothesis is rejected, then  $x$  is said not to “Granger-cause”  $y$ . Specifically, we use the following  $F$ -value

$$F = \frac{(RSS_0 - RSS_1)/p}{RSS_1/(T - 2p - 1)} \tag{2}$$

where  $RSS_1$  is the sum of squared residuals of equation (1) and  $RSS_0$  is the sum of squared residuals of equation (1) with the restriction that  $\beta_1 = \beta_2 = \dots = \beta_p = 0$ . The  $F$ -value is asymptotically distributed as  $F(p, T - 2p - 1)$ .

## 4 Empirical Results

### 4.1 Data and Summary Statistics

The yen swap rates used in this study are the weekly quotations obtained from the Data Resources Inc. (DRI) database for maturities of two-, three-, five-, seven-, and ten-years. These data were available for the period February 2, 1990 to December 30, 1999. To compute the swap spread, we use the par bond yields of Japanese Government Bonds (JGBs) with corresponding maturities, which were also obtained from the DRI database. The dollar swap spreads are from the DRI database for the same period, while the Constant Maturity Treasury bond (CMT) yield data are from the Federal Reserve Board's Release H15.

Figure 1 plots the weekly observations of yen swap rates for the period February 2, 1990 to December 30, 1999. These swap rates can be interpreted roughly as yields to maturity on bonds of the same maturity, priced at par. As the graph shows, yen swap rates have, in general, declined during the sample period. Typically, the swap rates increased with maturity (on each date, cross-sectionally), similar to the treasury term structure. Thus, for example, the ten-year curve lies above the two-year curve during most of the period. In other words, the swap yield curve was upward sloping during most of the sample period. However, it was inverted in 1990 and 1991: the ten-year rates were at or below the two-year rates during part of this period.

Table 1 provides the summary statistics of yen interest rate swap rates for the sample period. Panel A of the table presents the statistics in terms of the levels of the rates, and panel B in terms of first differences (changes from one week to the next). As seen in Figure 1, the term structure of yen swap rates for the sample period is, on average, upward-sloping i.e., the means increase with maturity. Also, the swap rates are persistent in a statistical sense and behave approximately like a random walk process, as is the case for yields in other markets. Although the autocorrelation coefficients of the swap rates are close to one, the rates may not exactly be a random walk process, since the standard deviations decline with swap maturity.

Panel B shows that the autocorrelations of the weekly changes in the swap rates, are somewhat larger than zero for all maturities, showing modest mean-reversion. However, the degree of mean-reversion is higher for the five-year maturity rates and lower for the ten-year maturity rates. The low degree of mean-reversion of long-maturity yields is consistent with the evidence for Treasury yields in many currencies. The panel also suggests that changes in the swap rates follow a non-normal distribution; hence, swap rates, like yields, in general, may not be well approximated by a lognormal process. Also, changes in the swap rates show (excess) positive skewness and kurtosis, relative to the normal distribution. The term structure of skewness increases as the maturity increases. One possible explanation for these characteristics may be the prevalence of discontinuous changes or jumps in the data, another common feature of interest rates.

We next analyze the spreads of yen interest rate swaps over the corresponding default-free rates measured on a constant maturity par-bond yield basis. Figure 2 presents the two- and ten-year yen swap spreads on a yield basis i.e., the difference between the yen swap rates and the par bond yields of JGBs with the corresponding maturity. As the graph shows, the two swap spreads moved together during most of the sample period. However, the two swap spreads behaved somewhat differently since mid-1997. Notice that the swap spreads for the ten-year maturity were positive during most of the sample period, although we do find a few cases of negative spreads in early 1990 and early 1999. However, two-year swap spreads turned negative in many cases. Out of 518 observations, 27.22 % and 1.93% of the swap spreads are negative for the two- and ten-year maturities, respectively.<sup>5</sup>

Panel A of Table 2 provides the mean, standard deviation and the autocorrelation coefficients for the yen swap spreads on a yield basis for various maturities. Panel B provides the same statistics for the first differences in yen swap spreads. As Panel A of Table 2 shows, the average spreads of yen interest rate swaps, over the corresponding JGBs, in terms of yields, as a function of maturity, show a slightly humped shape. The humped shape of the yen interest rate swap spread is also very different from the empirical pattern of the corporate bond spreads in the U.S., as documented by Sarig and Warga (1989) and Fons (1994). Those authors find that the average credit yield spread for investment-grade firms is upward sloping with maturity, while the credit yield spread is humped or inverted for speculative-grade firms. A recent paper by Helwege and Turner (1999), however, finds that the credit yield spread is, on average, upward sloping even for BB- or B-rated firms when the sample selection bias problem is corrected. Also, the swap spreads are persistent in a statistical sense and behave approximately like a random walk process, as is the case for swap rates. The standard deviations of swap spreads decline as the swap maturity increases, indicating that swap spreads may not exactly be a random walk process. The panel also suggests that the swap spreads follow a non-normal distribution. Relative to the normal distribution, the swap spreads show negative (excess) skewness for most maturities except for the ten-year, and the term structure of skewness increases as the maturity increases. Panel B of Table 2 shows that changes in swap spreads show negative (excess) skewness and kurtosis, and the term structures of skewness and kurtosis increase with maturity.

Figure 3 presents the two- and ten-year dollar swap spreads on a yield basis. As the graph shows, the ten-year dollar swap spreads were larger than the two-year spreads during most of the period. One noticeable pattern in the dollar swap spreads is that they have been on an increasing trend since mid-1997 when the Asian financial crisis erupted. The dollar swap spreads also showed a sharp spike during August and September 1998, when Russia defaulted on its sovereign debt and LTCM, the hedge fund, hovered near collapse, threatening the integrity of global bond and swap markets.

Another striking difference between dollar and yen swap spreads is that there are many

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<sup>5</sup>For other maturities also, the yen swap spreads are negative during a significant proportion of the sample period. Negative spreads account for 28.95%, 23.35% and 13.51 % of the spreads with three-, five- and seven-year maturities.

cases of negative spreads in the yen interest rate swaps, while dollar swap spreads were never negative in our sample period. As mentioned above, negative spreads are more pronounced as the maturity decreases. One possible explanation of negative spreads for the shorter maturity swaps is the difference in liquidity between swaps and JGBs. In general, the bond yields of illiquid bonds should be higher than those of liquid bonds. Empirical studies in the U.S. Treasury market such as Amihud and Mendelson (1991) and Elton and Green (1998) show that there is a significant price effect due to differences in the liquidity of bonds. This effect was especially important in the Japanese bond market until recently, since the liquidity effect was exacerbated due to the heavy concentration of trading in the ten-year benchmark bond. Thus, illiquidity of non-benchmark bonds tends to increase the par bond yields of Government bonds, while swap rates for the standard maturities are unaffected. This lowers the interest rate swap spreads relative to Government bond yields with corresponding maturities.

Panel A of Table 3 provides the mean, standard deviation and the autocorrelation coefficient for dollar swap spreads. As Panel A of Table 2 shows, the average spreads of dollar interest rate swaps show an upward-sloping shape, which is consistent with the empirical pattern of the corporate bond spreads in the US. Interestingly, the average swap spreads of dollar interest rate swaps are about twice those of yen interest rate swaps.<sup>6</sup> However, the standard deviations of dollar swap spreads are much smaller than those of yen swap spreads for most maturities, except for the ten-year maturity. Also, the dollar swap spreads are persistent and behave approximately like a random walk process, and the degree of mean reversion is somewhat smaller than that of yen swap spreads. Panel B of Table 3 shows that the changes in dollar swap spreads, relative to the normal distribution, show (excess) skewness and kurtosis.

## 4.2 Intermarket Linkage: The Evidence

We analyze the relationship between the swap spreads denominated in yen compared with those in the other major currency, the U.S. dollar. Table 4 presents the correlation coefficients between the changes in the yen interest rate swap spreads, the changes in the dollar interest rate swap spreads, and the changes in the interest rate differentials between the U.S. and Japan. Recall that the interest rate differentials are based on the constant maturity yields of government bonds of the same maturities with swaps. To avoid spurious correlation due to persistence in the swap spreads, we analyze the correlations between changes in these variables and not their levels.

Given the increasing globalization of trade and finance, we would expect that interna-

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<sup>6</sup>This difference is accounted for by several factors. First, the supply of U.S. Treasury bonds is shrinking while that of JGBs is growing. At the same time, the global appetite for U.S. Treasury bonds as a safe-haven asset is growing. These supply-demand effects cause a relative decline in U.S. Treasury yields and a relative increase in JGB yields. Second, the “repo” rate-LIBOR spread is lower in yen than dollars, creating a lower bound for the yen swap rate. Lastly, credit factors are different in the two currencies.

tional capital markets are highly integrated. In particular, the relative value trades of hedge funds such as LTCM are likely to accentuate this integration. Thus, if swap spreads reflect mainly the counterparty risk and/or default risk of large corporate issuers with global operations, the credit risk should be, at least to some extent, a global factor. Hence, swap spreads in yen and dollars should be highly correlated. However, the actual correlations between swap spreads in yen versus dollar interest rate swaps are surprisingly low. For example, the correlation for the two-year swap spread is negligible at 0.00404. The correlations between swap spreads for other maturities are also quite small, ranging from 0.00231 to 0.08526.

The changes in the swap spreads for yen interest rate swaps are more correlated with the changes in the interest rate differentials between the two markets. For example, the correlation coefficient between the two-year yen interest rate swap spread and the interest rate differential, which is defined as the two-year U.S. government par bond yield minus the two-year JGB par bond yield, is 0.44358. For other maturities, the coefficient of correlation ranges from 0.32317 to 0.40054. The change in the spread of dollar interest rate swaps is, however, uncorrelated with the change in the interest rate differential. For example, the coefficient of correlation between the five-year dollar interest rate swap spread and the interest rate differential is -0.07090. For other maturities, the coefficients of correlation between the dollar swap spread and the interest rate differential are almost zero, ranging from -0.00642 to -0.02722.

A possible explanation for the high correlation between the yen interest rate swap spread and the interest rate differential is that arbitrageurs go long yen interest rate swaps and go short dollar interest rate swaps to construct a spread position between the Treasury bonds (usually in the respective futures contracts) in the two countries. Such a spread is constructed to take advantage of the differential between the low long-term yields of JGBs and the high long-term yields of U.S. bonds. For instance, international corporations borrow in yen, then swap out of yen into dollars, using the proceeds for dollar investments. Hence, the yen swap rate is higher due to the demand for “pay-fixed” yen swaps.

To analyze the relation between the two interest rate swap spreads further, the changes in the yen interest rate swap spreads are regressed on (1) their own lagged values, (2) the lagged changes in the dollar interest rate swap spreads. Specifically, we perform the “Granger-causality” test to see if the lagged changes in the spreads for dollar interest rate swaps cause the changes in spreads of yen interest rate swaps. Since the “Granger-causality” test might be sensitive to the choice of number of lags, we perform the test for two, three and four lags. Only the test results for two lags are reported in Panel A of Table 5 for the entire sample period, because the overall test results for other choices of lags are qualitatively similar. As shown in Panel A of Table 5, the  $F$ -value of the “Granger-causality” test for the ten-year maturity is 3.95506, which is statistically significant at the 5% level. Thus, the lagged changes in the spreads for dollar interest rate swaps “Granger-cause” the changes in spreads of yen interest rate swaps for the ten-year maturities. However, the causality does not run the other way. For the case of dollar interest rate swaps with a maturity of ten years, the lagged changes of spreads in the yen interest rate swaps do not have the same

impact on the spreads in dollar interest rate swaps. Thus, for the long-end of the swap curve, there are spillover effects from the changes of spreads in dollar interest rate swaps to the yen interest rate swap market. For other maturities, there is no significant evidence that the lagged changes in the spreads for dollar interest rate swaps “Granger-cause” the changes in spreads of yen interest rate swaps, and *vice versa*.

More importantly, the lagged changes of interest differentials “Granger-cause” the increase in the spreads of yen interest rate swaps for all maturities. For example, the  $F$ -value of the “Granger-causality” test for 2-year maturity is 3.44010, which is statistically significant at the 5% significance level. For other maturities,  $F$ -values are statistically significant at the 1% significance level. However, the lagged changes in the interest rate differentials do not “Granger-cause” the increase in spreads of dollar interest rate swaps for most maturities except for two-year swaps. The  $F$ -value of the “Granger-causality” test for dollar swap spreads with maturity of 2 years is 3.70147, which is statistically significant at the 5% level. However, since  $F$ -values for other maturities range from 0.14441 to 0.72798, the hypothesis that the lagged changes in the interest rate differentials “Granger-cause” the changes in spreads of dollar interest rate swaps cannot be rejected. These results are consistent with the hypothesis that yen interest rate swaps are used as a part of a spread position created due to market frictions in the JGB market, e.g., the difficulty in going short JGBs. Hence, the demand for swaps induced by such frictions may have an impact on the swap rates. The frictions are smaller in the dollar market, since short sales restrictions are less binding in the U.S. Treasury bond market.

As noted earlier, there were significant credit events that rocked the global swap markets between the middle of 1997 and the end of 1998. Apart from the Asian financial crisis in the middle of 1997, the Russian default and the problems of LTCM in August-October 1998, there were other events in the Japanese markets, during this period. In 1997, the Japanese financial system also underwent serious credit problems due to the Asian crisis and the failures of several major financial institutions. We, therefore, next split the sample period into two sub-periods, until April 1997 (90.2 - 97.4) and from September 1997 (97.9 - 99.12), and check whether the empirical results of the “Granger-causality” test are sensitive to the choice of the sample periods. Panel B of Table 5 shows the test results for the first period. Unlike the total sample period, there is no evidence that the lagged changes in the spreads for dollar interest rate swaps “Granger-cause” the changes in spreads of yen interest rate swaps for the ten-year maturity. However, there is strong evidence that the lagged changes of interest differentials between the U.S. and Japanese Treasury yields “Granger-cause” the changes in the yen interest rate swap spreads for all maturities. Panel C of Table 5 also shows the test results for the second period. The empirical results show that changes in the interest differentials “Granger-cause” the changes in the spreads of seven- and ten-year yen interest rate swaps. There is also some evidence that changes in the yen swap spreads “Granger-cause” the changes in the interest differentials for the two- and ten-year maturities.

## 5 Conclusion

In this paper, we investigate the issue of market integration between the Japanese yen and the U.S. dollar interest rate swap markets during the period from February 1990 to December 1999. We obtain measures of the spreads of the swap rates over comparable treasury yields, those on JGBs and U.S. Treasury bonds respectively, for different maturities, and analyze the relationship of credit risk between the swap spreads in the two markets.

Our empirical results show that the credit risk factor in the swap markets is country-specific rather than global in nature, given the low correlations between yen and dollar interest swap spreads. Furthermore, changes in the dollar interest rate swaps “Granger-cause” the changes in the yen interest rate swap spreads, at least for the ten-year maturities, indicating that yen swap markets may not be informationally efficient. We, however, do not find any evidence that dollar swap spreads are affected by yen interest rate swap spreads. Instead, we find that yen swap spreads are highly correlated with the interest rate differentials between the two markets, while dollar swap spreads have virtually zero correlations with the interest rate differentials. Interest rate differentials between these two markets also “Granger-cause” the changes in the spreads of yen interest rate swaps across all maturities. These empirical results imply that yen swap spreads are partly determined by market-specific activity in the yen fixed income markets. When we test the sensitivity of our results for different sub-periods, we find similar results; our results seem to be robust to the choice of the sample period.

Although we find some interesting results on the inter-market relationship between the yen and dollar swap markets, there is a puzzling issue that needs to be addressed further. In the case of dollar swap spreads, we find no case where the interest swap spreads become negative. However, we find that the yen swap spreads were negative for a significant length of time, especially in early 1999. Given the fact that we find a few cases of negative spreads for ten-year swaps, one possible explanation is that this phenomenon arises from the illiquidity of JGBs with maturities other than the on-the-run (often the benchmark) ten-year tenor. Since the level of yen interest swap spreads is extremely low or even negative in that period, it would be important to measure the swap spreads using alternative par bond yields of JGBs to test if there existed arbitrage opportunities in yen interest swap markets. This issue is left for future research.

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**Table 1. Summary Statistics of the Yen Swap Rate**

Panel A provides the mean, standard deviation, skewness, kurtosis and autocorrelation coefficient for weekly yen swap rates for swaps of maturities from two years to ten years for the period February 2, 1990 to December 30, 1999. The number of observations is 518. The quotations were obtained from the Data Resources Inc. database. Panel B provides the same summary statistics for the first differences of the Yen swap rates.

**Panel A: Level**

Maturity	MEAN	ST DEV	SKEWNESS	KURTOSIS	AUTO
2 year	2.98744	2.48615	0.79866	-0.66049	0.99512
3 year	3.24954	2.37073	0.66801	-0.83208	0.99512
5 year	3.68450	2.14930	0.47465	-1.02091	0.99490
7 year	4.00347	1.97043	0.34597	-1.09000	0.99506
10 year	4.20280	1.79625	0.32782	-1.06157	0.99488

**Panel B: First Differences**

Maturity	MEAN	ST DEV	SKEWNESS	KURTOSIS	AUTO
2 year	-0.01326	0.10745	0.00677	1.34628	0.03195
3 year	-0.01281	0.11126	0.05033	1.42595	0.04352
5 year	-0.01144	0.11026	0.19437	1.16084	0.04468
7 year	-0.01031	0.10201	0.34716	1.07130	0.03944
10 year	-0.00947	0.09756	0.36465	1.40169	0.02945

**Table 2. Summary Statistics of the Yen Swap Spreads**

Panel A provides the mean, standard deviation, skewness, kurtosis and autocorrelation coefficient for weekly yen swap spreads, the difference between swap rates and the par bond yields of JGBs with the corresponding maturity, for swaps of maturities from two years to ten years for the period February 2, 1990 to December 30, 1999. The yen swap rates and the par bond yields of JGBs are obtained from the Data Resources Inc. database. Panel B provides the same summary statistics for the first differences of the Yen swap spreads.

**Panel A: Level**

Maturity	MEAN	ST DEV	SKEWNESS	KURTOSIS	AUTO
2 year	0.14681	0.26752	-0.66396	0.00427	0.92699
3 year	0.21186	0.34331	-0.50595	-0.15210	0.95939
5 year	0.27464	0.34310	-0.24395	-0.17435	0.96850
7 year	0.21292	0.21237	-0.16490	0.59086	0.94390
10 year	0.23974	0.13422	0.28691	0.28932	0.84121

**Panel B: First Differences**

Maturity	MEAN	ST DEV	SKEWNESS	KURTOSIS	AUTO
2 year	-0.00155	0.09921	-0.70747	6.64232	-0.33102
3 year	-0.00158	0.09446	-0.74705	5.35432	-0.28145
5 year	-0.00127	0.08370	-0.51047	4.88673	-0.16920
7 year	-0.00062	0.07005	-0.35815	2.86059	-0.21088
10 year	-0.00036	0.07428	-0.32289	4.60559	-0.33789

**Table 3. Summary Statistics of the Dollar Swap Spreads**

Panel A provides the mean, standard deviation, skewness, kurtosis and autocorrelation coefficient for weekly Dollar swap spreads for swaps of maturities from two years to ten years for the period February 2, 1990 to December 30, 1999. The spreads of the U.S. dollar interest rate swaps are obtained from the Data Resources Inc. database. Panel B provides the same summary statistics for the first differences of the Dollar swap spreads.

**Panel A: Level**

Maturity	MEAN	ST DEV	SKEWNESS	KURTOSIS	AUTO
2 year	0.32928	0.14727	0.55479	-0.83208	0.96232
3 year	0.40524	0.16498	0.45942	-1.03331	0.97059
5 year	0.42769	0.19144	0.77209	-0.76183	0.98438
7 year	0.47710	0.17753	0.93210	-0.28339	0.98274
10 year	0.50853	0.18865	0.99706	-0.24416	0.98512

**Panel B: First Differences**

Maturity	MEAN	ST DEV	SKEWNESS	KURTOSIS	AUTO
2 year	0.00246	0.03704	-0.26928	5.32819	-0.13963
3 year	0.00282	0.03758	0.47058	5.42454	-0.03437
5 year	0.00325	0.03739	1.44794	7.75941	0.03895
7 year	0.00311	0.03734	1.11548	6.48343	0.04289
10 year	0.00318	0.03724	1.50610	8.03769	0.01297

**Table 4. The Relationship between the Yen and Dollar Swap Spreads**

This table presents the correlation coefficients among the changes in the yen interest rate swap spreads, JPSPREAD, the changes in the dollar interest rate swap spreads, USSPREAD, and the changes in the interest differentials between U.S. and Japan, DIFF for different maturities. The interest rate differentials are based on the constant maturity yields of government bonds of the same maturities as the swaps. Weekly observations of swap spreads and the constant maturity yields are based on data obtained from the Data Resources Inc. for the period February 2, 1990 to December 30, 1999.

**Panel A: Two-year**

	USSPREAD	JPSPREAD	DIFF
USSPREAD	1	0.00404	-0.0100
JPSPREAD		1	0.44358
DIFF			1

**Panel B: Three-year**

	USSPREAD	JPSPREAD	DIFF
USSPREAD	1	0.08526	-0.00642
JPSPREAD		1	0.39967
DIFF			1

**Panel C: Five-year**

	USSPREAD	JPSPREAD	DIFF
USSPREAD	1	0.00231	-0.0709
JPSPREAD		1	0.40054
DIFF			1

**Panel D: Seven-year**

	USSPREAD	JPSPREAD	DIFF
USSPREAD	1	0.00664	-0.02722
JPSPREAD		1	0.32317
DIFF			1

**Panel E: Ten-year**

	USSPREAD	JPSPREAD	DIFF
USSPREAD	1	0.01470	-0.00680
JPSPREAD		1	0.34285
DIFF			1

**Table 5. The Lead-Lag Relationship between the Yen and Dollar Swap Spreads**

Panel A presents the results of bivariate “Granger-causality” tests among changes in the yen interest rate swap spreads ( $JPSpread_t$ ), changes in the dollar interest rate swap spreads ( $USSpread_t$ ), and the lagged changes in the interest rate differentials between the U.S. dollar and Japanese yen ( $Diff_t$ ) for the period February 2, 1990 to December 30, 1999. The interest rate differentials are based on the constant maturity yields of government bonds of the same maturities as the swaps. Weekly observations of swap spreads and the constant maturity yields are obtained from the Data Resources Inc. Numbers in the table represent the  $F$ -values of the “Granger-causality” test with the numbers in brackets representing the corresponding  $p$ -values. Panel B and panel C provide the same test statistics for the first and second sub-periods, 90.2 - 97.4 and 97.5-99.12, respectively.

**Panel A: TOTAL PERIOD**

	2 year	3 year	5 year	7 year	10 year
$JPSpread \rightarrow USSpread$	0.18219 (0.83349)	1.48063 (0.22846)	0.06487 (0.93719)	0.78579 (0.45631)	2.14937 (0.11761)
$JPSpread \rightarrow Diff$	6.24511 (0.00209)	2.33229 (0.09810)	1.97277 (0.14013)	1.33554 (0.26393)	5.00991 (0.00700)
$USSpread \rightarrow JPSpread$	0.38807 (0.67856)	0.95681 (0.38480)	0.66595 (0.51423)	0.94626 (0.38887)	3.95506 (0.01974)
$USSpread \rightarrow Diff$	0.27057 (0.76305)	0.35660 (0.70022)	0.12236 (0.88485)	0.27856 (0.75698)	0.02660 (0.97375)
$Diff \rightarrow JPSpread$	3.44010 (0.03280)	6.12350 (0.00235)	5.81857 (0.00317)	7.39058 (0.00068)	5.70599 (0.00354)
$Diff \rightarrow USSpread$	3.70147 (0.02535)	0.56072 (0.57115)	0.72798 (0.48338)	0.21271 (0.80846)	0.14441 (0.86556)

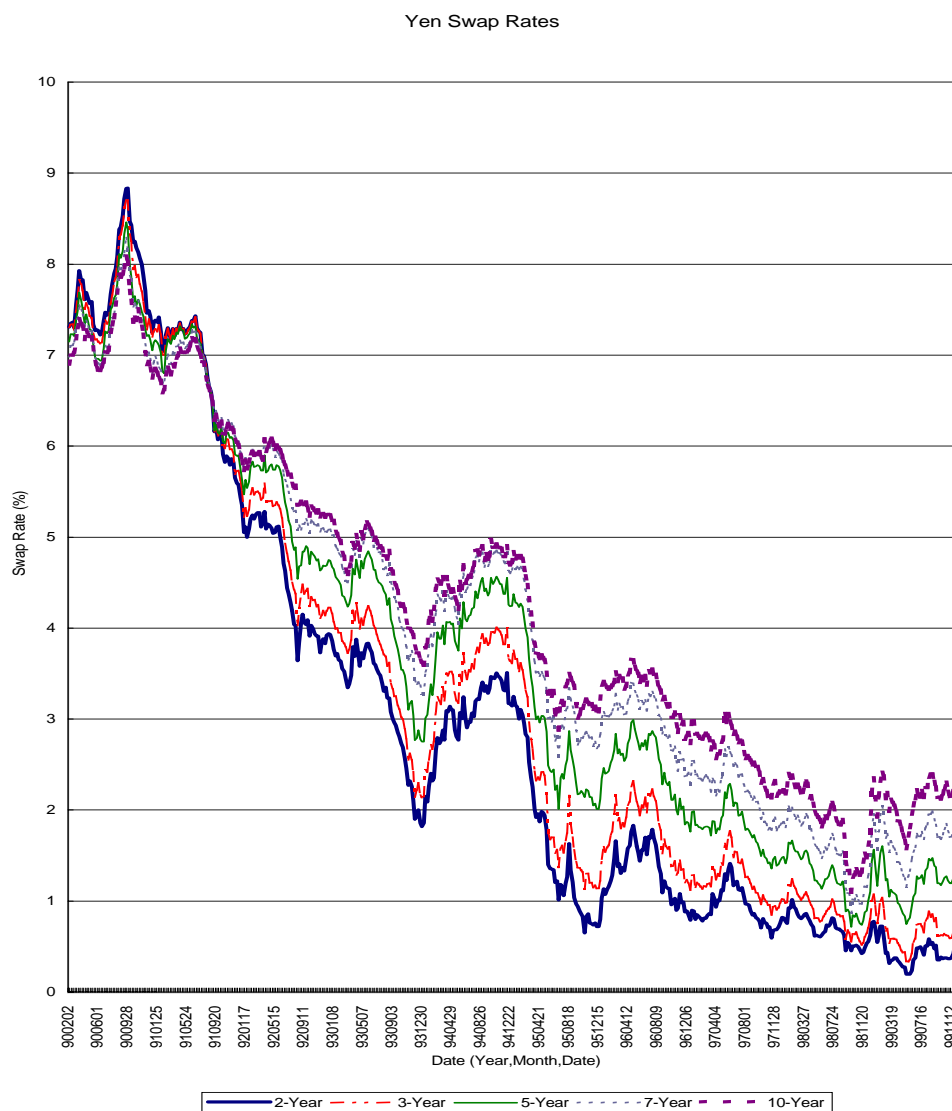
**Panel B: FIRST SUB-PERIOD: 90.2 - 97.4**

	2 year	3 year	5 year	7 year	10 year
$JPSpread \rightarrow USSpread$	0.17537 (0.83921)	1.63274 (0.19679)	0.12585 (0.88178)	0.16486 (0.84807)	0.32060 (0.72591)
$JPSpread \rightarrow Diff$	2.32624 (0.09908)	0.95070 (0.38741)	2.34042 (0.09771)	0.69621 (0.49912)	0.42323 (0.65524)
$USSpread \rightarrow JPSpread$	0.19691 (0.82135)	0.63292 (0.53161)	0.80721 (0.44688)	0.07436 (0.92834)	0.56710 (0.56766)
$USSpread \rightarrow Diff$	0.45837 (0.63266)	1.80770 (0.16547)	3.30486 (0.03779)	3.61196 (0.02795)	2.82760 (0.06043)
$Diff \rightarrow JPSpread$	7.36662 (0.00072)	11.84393 (0.00001)	8.00672 (0.00039)	5.04518 (0.00689)	3.66729 (0.02647)
$Diff \rightarrow USSpread$	2.09942 (0.12398)	0.17797 (0.83704)	0.11391 (0.89237)	0.02708 (0.97328)	0.00433 (0.99567)

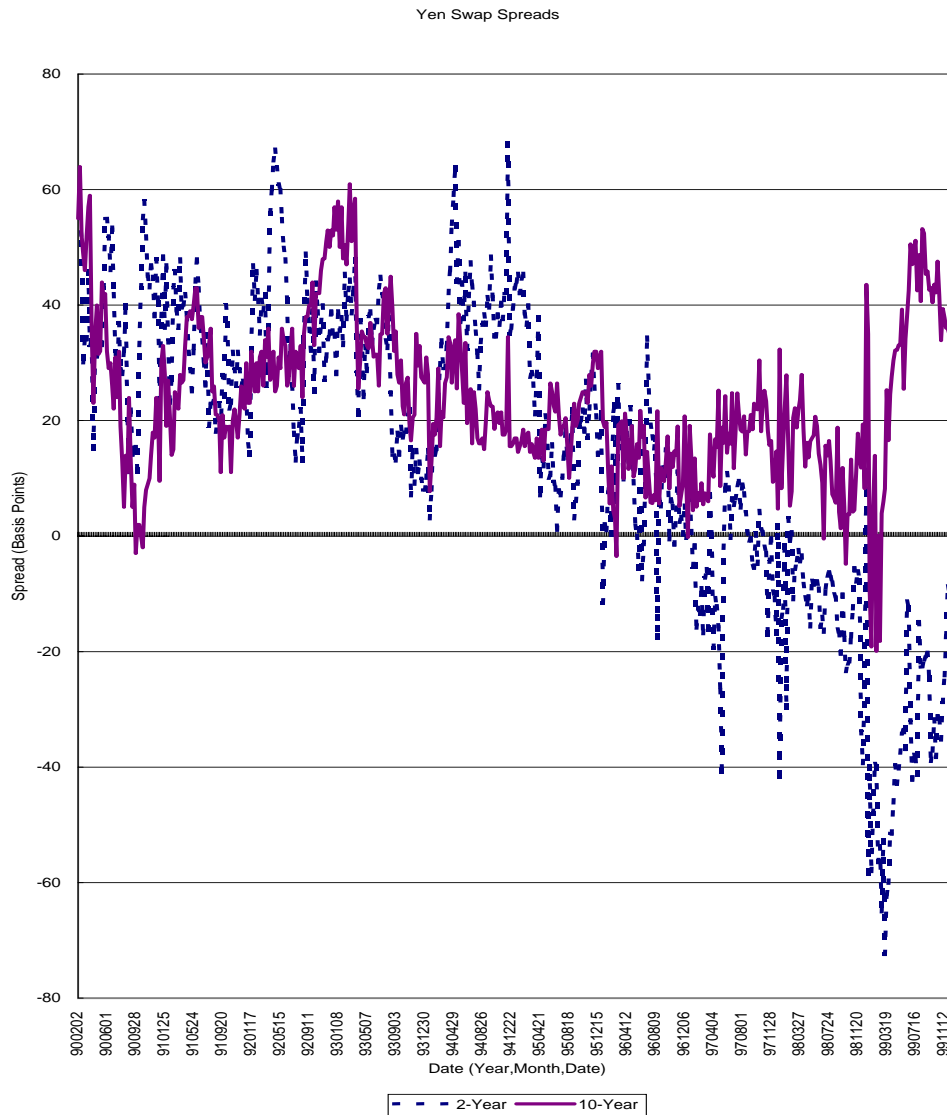
**Panel C: SECOND SUB-PERIOD: 97.5 - 99.12**

	2 year	3 year	5 year	7 year	10 year
JPSpread → USSpread	1.07965 (0.34263)	0.77947 (0.46070)	0.60445 (0.54784)	0.58104 (0.56070)	1.33096 (0.26766)
JPSpread → Diff	2.66289 (0.07340)	0.87711 (0.41833)	0.50458 (0.60489)	0.60189 (0.54923)	6.80388 (0.00153)
USSpread → JPSpread	0.09549 (0.90898)	0.25044 (0.77881)	1.02474 (0.36166)	1.20868 (0.30180)	2.30365 (0.10380)
USSpread → Diff	0.44211 (0.64360)	1.08246 (0.34168)	1.62145 (0.20143)	1.18618 (0.30854)	1.69988 (0.18659)
Diff → JPSpread	0.41100 (0.66381)	0.71255 (0.49222)	0.73509 (0.48137)	4.44881 (0.01345)	5.27228 (0.00624)
Diff → USSpread	6.56807 (0.00189)	5.34897 (0.00581)	1.78502 (0.17173)	0.58791 (0.55690)	0.26849 (0.76493)

Figure 1: **Yen Swap Rates.** This figure presents the time series graphs of yen swap rates in percent for maturities from two years to ten years for the period February 2, 1990 to December 30, 1999 on a weekly basis. The swap quotations are obtained from the Data Resources Inc. database.



**Figure 2: Yen Swap Spreads.** This figure presents the two- and ten-year yen swap yield spreads, the differences between the yen swap rates and the par bond yields of JGB's with the corresponding maturity, for the period February 2, 1990 to December 30, 1999 on a weekly basis. The yen swap rates and the par bond yields of JGBs are obtained from the Data Resources Inc. database.



**Figure 3: Dollar Swap Spreads.** This figure presents the time series graphs of the two- and ten-year dollar swap spreads for the period February 2, 1990 to December. The spreads of the U.S. dollar interest rate swaps are obtained from the Data Resources Inc. database.

