증권 · 금융저널 제2권1호(2003.2)

The Time-Series Behaviour of Credit Spreads on Yen Eurobonds

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<Abstract>

Straight fixed rate Yen denominated Eurobonds represent the largest market segment after U.S. dollar denominated issues. The objective of this paper is to investigate the time series behaviour and the efficiency of the markets for credit spreads between different risk and maturity classes of Yen denominated Eurobonds. We find that the credit spreads were time-varying and the return series were inefficient though those results may have been due to differences in liquidity between the different credit classes and maturities of bonds. The implications of these results for credit spread derivatives is examined.

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I. Introduction

The credit spread is the difference in the yields between different risk or ratings classes of securities with the same maturity. The objective of this paper is to investigate the times series behaviour and efficiency of the markets for credit spreads between AAA and AA rated Yen denominated Eurobonds and the equivalent Japanese Government bond with maturities of 2, 3, 5, 7,10 and 20 years, from June 1993 to 21 October 1998 (1382 observations). Tests for market efficiency in stock and bond markets have been extensive (see Lee, Sung and Urrutia 1996) and hinge upon the original insight of Fama (1965) that the returns in weak form efficient markets are random walks, or IID processes, with zero mean, constant variance and lacking in autocorrelation.

There are a number of theoretical papers explaining the term structure of credit (e.g. Merton 1974, and Jarrow, Lando and Turnbull 1997), and others investigating the credit spread term structure of the U.S. corporate bond market (e.g. Sarig and Warga 1989, Fons 1994 and Helwege and Turner 1999). Since the Yen Eurobond market comprises some US$407.1 billion worth of outstanding bonds in 1998, making it the second largest market after the U.S. dollar, it is important that this behaviour be understood. Eurobonds are largely unsecured, with most issues by high quality issuers with AAA and AA ratings. These aggregated ratings classes represent portfolios of AAA and AA bonds issued by a variety of issuers from different industrial sectors across a range of different maturities. Understanding the stochastic properties of these classes of bonds is essential for portfolio managers who must benchmark their portfolios to market portfolios, to risk managers who need to understand bond price relationships when constructing dynamic hedges, and to traders in credit derivatives who speculate on the volatility of credit spreads. Credit derivatives are a new group of financial product which either synthetically replicates the credit features of a loan agreement, or emulates the behaviour of a put option on credit sensitive assets (The Bank of England 1996). A recent survey of market participants by Green, Locke and Paul-Choudhury (1998) estimated global market outstandings were over US$300 billion with a projected size of US$1,000 billion by the year 2000. This result suggests a trebling in the credit derivatives market since the British Bankers Association (1996) made earlier estimates.

The trading in one particular class of credit derivative, the credit spread derivative, involves establishing the margin between the return on one class, or rating, of bond or commercial paper and another one, often being the (credit) risk-free return on a government bond or treasury note which serves as the "benchmark" or reference security for pricing purposes. The margin between the two is the spread a comparison which depends on the time to maturity. Thus the essence of the credit spread contract, in whatever guise it may come, is the relative spread position or margin at maturity. Either party makes payment to the other depending on the spread being wider or narrower than the spread specified as the strike price in the contract at maturity. Therefore credit spread devices do not rest upon specified credit events as provided in the credit swap approach. Hence the spread is open to the influence of any happening including conjecture which can bear upon market outcomes. Thus the swap is directed to the preserving of asset value, as is the case with the credit-linked note, while the spread devices are about the securing of the income stream.

At first sight the opportunities offered by credit spreads appear to be comprehensive ranging from the complementing of swaps contracts off benchmark rates to the hedging of all sorts of income exposures including earnings from swap contracts as well as any market transactions involving spreads between risky assets. However the scope for this trading is constrained by the availability of data and related information on credit histories for the entities about which trades might best be sought. There are also practical aspects concerning the trading of spreads including the liquidity of the underlying bonds which are trading in secondary markets, and pricing concerns since market convention is to price Eurobonds as a spread over a continuous benchmark curve constructed from the observed yields of government bonds and the interpolated yields for the remaining maturities. This contribution provides a broader understanding of the time series processes driving the price changes.

Specifically, this investigation, focuses on identifying the underlying time series properties of credit spreads. Also, the underlying term structure of the credit spreads is examined. Originally Merton (1974) and more recently Jarrow, Lando and Turnbull (1997) predict that high grade issuers face upward sloping credit yield curves (that is the spread over the risk free asset rises with maturity) whereas speculative firms face the reverse situation; downward sloping, or hump shaped but downward sloping curves. The empirical evidence is mixed with Fons (1994) showing support for these theories using regression techniques based upon a sample of U.S. corporate bonds. However, Helwege and Turner (1999) using U.S. corporate bonds issued by the same firm but with a different maturity, find empirical support for the reverse position: contrary to the theoretical predictions of the bond pricing models, the credit yield curve for the speculative grade firm is upward sloping.

The results from this study suggest that the term structure of credit for AAA and AA issuers of Yen Eurobonds is in fact time varying. Other results also provide evidence of the leptokurtic nature of the return series. The series are also generally highly autocorrelated up to three lagged time periods which suggests the market is not weak-form efficient. The paper is structured as follows. Next (Section II) the Eurobond credit spread data is described. Then, in Section III the time series properties of the yen credit spreads are presented. The final section allows for some concluding remarks.

II. Yen Eurobond Credit Spread Data

For credit spread traders and sellers of credit spread options, it is important to determine the distributional qualities of the data to ensure pricing decisions are made correctly. Of particular concern is the distribution of interday returns and its four moments since most market valuation models (e.g. simple option pricing models) assume the distributions are normal. Risk managers also need to determine the frequency that daily changes in return lie outside the 98% confidence interval, the interval used for value at risk purposes.

To provide an insight into these pricing issues, we consider the behaviour of yield spreads, representing credit rating premiums, between two different ratings classes of Yen denominated Eurobonds (AAA and AA ratings) and the equivalent maturity Japanese Government security. We investigate these relationships for six different maturities (2 year, 3 year, 5 year, 7 year, 10 year and 20 year) from 9 January 1993 to 21 October 1998 (1382 daily observations) were investigated. The data was collected as a daily yield for each credit rating across 3 or 4 industries, then averaged. These included Industrial, Telecommunications, Banking and Finance, Utilities, Cable and Broadcasting. These prices were originally sourced from the Reuters' Fixed Income database which contains 3,210 yen denominated Eurobonds with a face value of US$232.90 billion in 1998.

(i) Background

Yen Eurobond yields generally fell over the sample period (20 year bond yields fell from near 5.8% in June 1993 to below 2.0% in October 1998). The different yields were also highly correlated. While bond yields generally fell for much of the sample period, following well documented and extensive central bank intervention, a series of Japanese fiscal initiatives and a pickup in growth in the US economy, the USD dollar appreciated for most of the later part of 1998 from the sample period highs of 140 Yen to the dollar to 110 Yen to the dollar.

The relationship between the fall in the yields on Yen bonds and the rise in the value of the USD against the Yen is highlighted by the negative correlation of -0.717 between the value of the spot USD-Yen and the yield on 20 year AAA (and also AA) rated bonds during the period. However, interday changes in the spot USD-Yen (S_t) expressed as first differences ($S_{t+1} - S_t$) were only slightly correlated to the changes in the levels of AAA and AA Yen bond rates. Though all correlations were positive and significantly greater than zero, the highest correlations were between the shorter maturity bonds (i.e. the positive correlation between changes in the log of the spot USD-Yen rate and the change in the level of the 20 year AAA bond was 0.075 compared with 0.094 for the 2 year AAA bond. This suggests that generally spot Yen volatility may not contribute to volatility in credit spreads, though select periods of currency volatility (clusters of volatility) had higher correlations to changes in the bond yields (e.g. in 1995 the interday change in the Yen and the interday change in the levels and returns of 20 year AAA bonds had a higher correlation of 0.15). This is consistent with a time varying correlation structure.

(ii) Liquidity

Inoue (1999) first reported the maturity structure of the domestic bond issues by the Japanese Government which at 1998 year-end totalled US$1,919 billion, making the Japanese Government bond market the second largest government bond market after the U.S. Government bond market. Inoue expressed concern at the concentration of Government issues (about 78%) in the 5 to 10 year maturity band, making short and

Table 1 Maturity Distribution of Japanese Government and Yen Eurobonds

Maturity of Bonds (as % of total)				
Credit Class	<5 years	5-10 years	> 10 years	Total
Outstanding (US$ Billion)				
Government	13	78	9	1,919
AAA	23	55	22	46.3(20%)
AA	15	75	101	16.9(50%)
A	51	37	12	40.6(17%)
BBB	50	49	1	15.9 (7%)
BB	48	49	3	8.3 (4%)
B	64	34	2	4.7 (2%)
CCC	100			0.1
D	100			0.1
Total Eurobonds Outstanding (US$ Billion)	27.9(12%)	232.90	63.5 (27%)	141.7 (61%)

Sources: The data for Japanese Government bonds was obtained from Inoue (1999). Eurobond data was obtained from the Reuters Fixed Income Database. The exchange rate was 1USD = 120 Yen.

longer maturity bonds relatively illiquid. While the Bank for International Settlements reports Eurobond outstandings in its quarterly series *of International Banking and Financial Market Developments*, the maturity structure is not reported. However, the Reuters Fixed Income Database records the prices and structure of the majority of yen Eurobonds which trade in secondary markets. Those bonds not included are generally bonds which were privately placed (and therefore not traded in secondary markets). Table 1 reports the maturity structure and outstandings of yen Eurobonds by credit rating and includes for comparison purposes the results of Inoues (1999) analysis of the Japanese Government bond market. In the Table, bond maturity is broadly classified as short (less than 5 years), medium (5 to 10 years) and long (more than 10 years).

Relative to the Japanese Government bond market, the yen Eurobond market is small with the Reuters Fixed Income Database recording US$232.90 billion of bonds in 1998. The majority of Eurobonds also have a medium maturity of 5 to 10 years (61%), which is less than in Government bond markets, though there are significantly more short-term issues (27%). Most issuers are investment grade, with the AA rating accounting for nearly 50% of outstanding bonds. High-quality AAA and AA issuers show a preference for longer bond issues (more than 5 years), while issuers with ratings better than B tend to issue short and medium term bonds equally. Though there are a few bonds issued with ratings below BB, these bonds usually have a short maturity. These results highlight the significance of this study since it investigates the pricing behaviour of the credit spreads of AAA and AA rated bonds which together account for 70% (US$163 billion) of Eurobonds available for trading in secondary markets.

III. Time Series Properties of the Yen Credit Spreads

Analysis of the bond yields also involved determining the descriptive statistics and correlation relationships between the different classes and maturities of bonds. These credit spreads represent the premium for credit risk between each group and maturity. Table 2 provides descriptive statistics of the credit spreads between the different classes and maturities of bonds, Tables 3 and 4 provide descriptive statistics, correlation, and autocorrelation relationships for the first differences (interday) changes in the credit spreads between the different credit classes and maturities of bonds. These changes in the credit spreads also represent the interday return to the spread trader. Later, Table 7 provides the results from stationarity tests.

Daily Yen Eurobond Credit Spreads (Levels) and Correlations

Table 2 records the four moments of the daily credit spreads between AAA and AA rated Yen bonds and the equivalent maturity government security (i.e. 2, 3, 5, 7, 10 and 20 year maturities. The mean and standard deviation of the AAA bond spreads

Table 2 Moments of the Daily Credit Spreads Between Different Ratings and Maturities of Yen Denominated Eurobonds and the Equivalent Maturity Japanese Government Security 9 June 1993 to 21 October 1998

This table records the four moments of the daily credit spreads between AAA and AA rated Yen bonds and the equivalent maturity government security (i.e.2, 3, 5, 7, 10 and 20 year maturities.

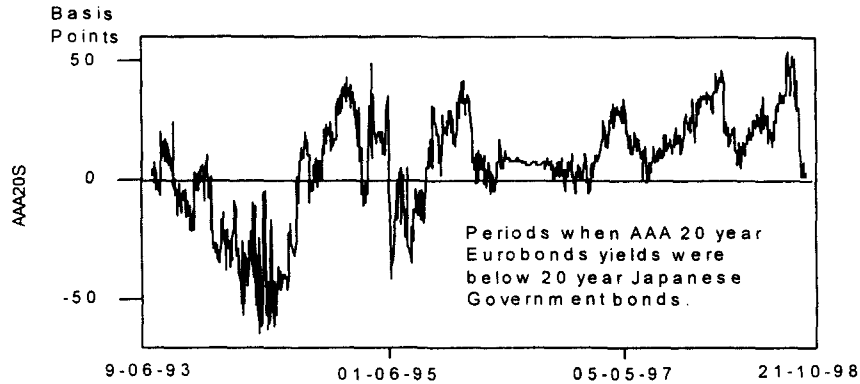
Credit Spread N = 1382 in basis points	Mean(basis points)	StandardDeviation (basis points)	Skewness	Excess kurtosis	Anderson Darling Normality test
AAA2	12.761	11.849	1.192	72.0811	27.247 p = 0.000
AAA3	18.088	17.513	0.5644	0.09670	9.016 p = 0.000
AAA5	14.145	13.281	0.9884	0.2029	65.758 p = 0.000
AAA7	9.525	8.498	1.3541	2.2974	72.440 p = 0.000
AAA10	6.271	6.297	0.0233	1.4659	12.466 p = 0.000
AAA20	6.371	7.526	0.8500	0.65477	24.122 p = 0.000
AA2	17.999	16.684	1.4114	2.8437	39.593 p = 0.000
AA3	23.509	22.358	0.9969	1.16101	9.107 p = 0.000
AA5	20.125	19.087	1.0892	0.2806	76.007 p = 0.000
AA7	15.212	13.892	1.5063	1.92082	89.298 p = 0.000
AA10	20.2480	19.504	1.1745	1.4847	43.252 p = 0.000
AA20	18.335	19.639	0.0940	1.3845	16.799 p = 0.000

generally fell with increasing maturity (a negative credit term structure), while the mean spreads and standard deviation on the lower quality AA bonds were more variable with increasing maturity (suggesting a humped credit term structure). None of the series were significantly skewed with most results close to 1, though the AAA2, AAA7, AA2 and AA7 spread series display significant excess kurtosis (leptokurtosis). It also appears that the more liquid categories of bonds (those bonds with 5 to 10 year maturities) have slightly different price behaviour than shorter or longer maturities.

Note the negative and humped credit curves for the AAA and AA issuers are inconsistent with the upward sloping credit curves predicted by Merton (1974) and Jarrow, Lando and Turnbull (1997) for high grade issuers.

Figure 1 Daily AAA Rated 20 Year Yen Denominated Eurobond Spread to 20 Year Japanese Government Security 9 June 1993 to 21 October 1998

This figure shows the time varying nature of the daily credit spread between the 20 year AAA rated bond and the equivalent 20 year Japanese Government security for the period from 9 June 1993 to 21 October 1998

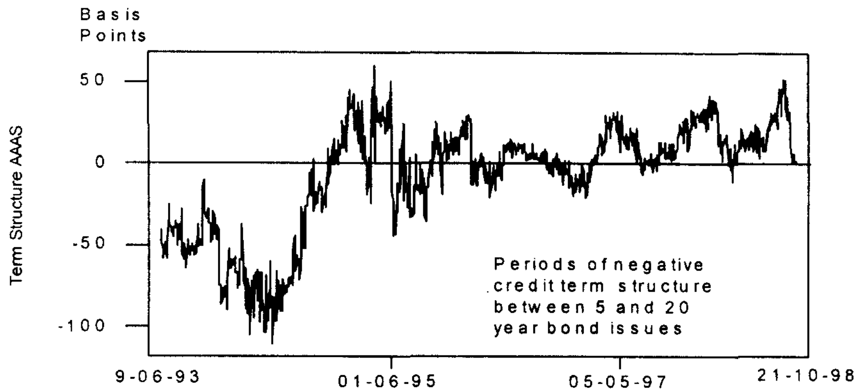


The final column displays the result of a normality test (Anderson-Darling Chi-Squared based test) which suggests that at a > 0.000 there is evidence that all the series do not follow a normal distribution due largely to the leptokurtic nature of the distributions. Leptokurtosis is commonly found in financial time series where there are periodic jumps in asset prices due to the effects of discontinuous trading. These jumps in prices may create hedging problems for risk managers when assets move outside the confidence intervals established for prudential controls.

The behaviour of the credit spreads during the sample period is illustrated in Figure 1, which plots the yield spread or margin between the 20 AAA Eurobond and the 20 year Japanese Government bond. During the sample period the credit spread on the 20 year AAA bond was generally positive though there were two prolonged periods when the 20 year AAA Eurobond yield was below the equivalent maturity Japanese Government bond: the period from September 1993 to September 1994, and the period

Figure 2 Daily AAA Rated 5 to 20 Yen Denominated Eurobond Spread 9 June 1993 to 21 October 1998

This figure shows the time varying nature of the credit term structure between the spread on the 20 year AAA rated bond and the equivalent 5 year AAA rated Eurobond for the period from 9 June 1993 to 21 October 1998. The spread is measured in basis points.



of extensive central bank intervention around June 1995. We attribute this result to portfolio adjustments between Yen Eurobonds and domestic Yen Government bonds. We suggest investors were buying USD against the Yen in the spot markets, then selling Japanese Government bonds and buying USD, or substituting Japanese Government bonds for non-Japanese, though still AAA rated, Yen denominated Eurobonds. More recently the spread has narrowed with the 20 year AAA bond yield now slightly above the 20 year Japanese Government bond yield.

Figure 2 shows the time varying nature of the credit term structure between the spread on the 20 year AAA rated bond and the equivalent 5 year AAA rated Eurobond for the period from 9 June 1993 to 21 October 1998. The spread is measured in basis points. This spread was also highly correlated to the credit term structure on AA rated bonds (the correlation between the 5 to 20 year AA and AAA rated bonds was 0.906). Consistent with Merton (1974) and Jarrow, Lando and Turnbull (1997) for most of the sample period the term structure of credit for AAA issuers was positive (i.e. high grade issuers faced upward sloping credit yield curves). However in the earlier period of the sample, from June 1993 to December 1994, the term structure was negative, while towards the end of the sample period the term structure was near par, that is a AAA issuer could issue at the same spread to Japanese government securities for either 20 year bonds or 5 year bonds. This figure suggests that the credit term structure identified by other researchers including Helwege and Turner (1999) for US bonds may in fact be time varying. This result may be interpreted as investors either having time varying expectations about what defines a risky security, that is investors perceptions of the riskiness of a ratings class relative to a riskless security is non-constant when expressed as a margin in basis points.

The correlations of the credit spreads between the various rating classes and maturities tended to be positive and suggests significant co-movement between credit spreads for most maturities. The correlations were mostly positive and highest for the credit spreads of the same risk class but with different maturities (e.g. AAA2 year and AAA3 year with a correlation of 0.860). The negative correlations for the 20 year AAA and AA spreads suggests credit spreads on longer maturities rose (or fell) relative to falls (or rises) in shorter maturities over the sample period and may have been due to a pivoting in the yield curve. The levels of credit spreads were also highly positively autocorrelated and were significant to the 60-70 lag period. The very slow decay of the autocorrelation structure is indicative of an autoregressive process.

(b) Interday Yen Eurobond First Differences (Returns)

Descriptive statistics (four moments) of the first differences (daily returns) in the credit spreads between Yen denominated Eurobonds with AAA and AA ratings and maturities of 2, 3, 5, 7, 10 and 20 years and the equivalent Japanese Government security are presented in Table 3. The mean for all series was close to zero, and the median for all series (not recorded in the table) was zeros. The standard deviation (s) of the AAA and AA bond spread returns generally rose with increasing maturity (e.g. AAA 20 year returns had s =5.994, while the AAA 2 year had s = 5.3884), while the AAA spread returns were generally less volatile than the AA (e.g. AAA 2 year s = 5.388 < AA2 year s = 5.676). None of the return series were significantly skewed with most results close to 0, though all the series (in particular the shorter and longer maturities) display significant excess kurtosis (leptokurtosis). This observation is consistent with the earlier finding that the shorter and longer bond maturities have similar time series properties, and these properties differ to those bonds with medium term maturities.

The Table also displays the results from a two-tailed Z-statistic which tests the null hypothesis that the series mean is equal to zero- one of the requirements for random walk processes. Each of the series fails this simple test. In addition the non-parametric runs test for randomness was conducted on the returns. In each of the series the observed number of runs > expected number of runs, characteristic of a series which displays negative autocorrelation. This was in fact confirmed when formal tests for autocorrelation where conducted. However the runs test results reject the presence of randomness in each of the series at the 99.9% level.

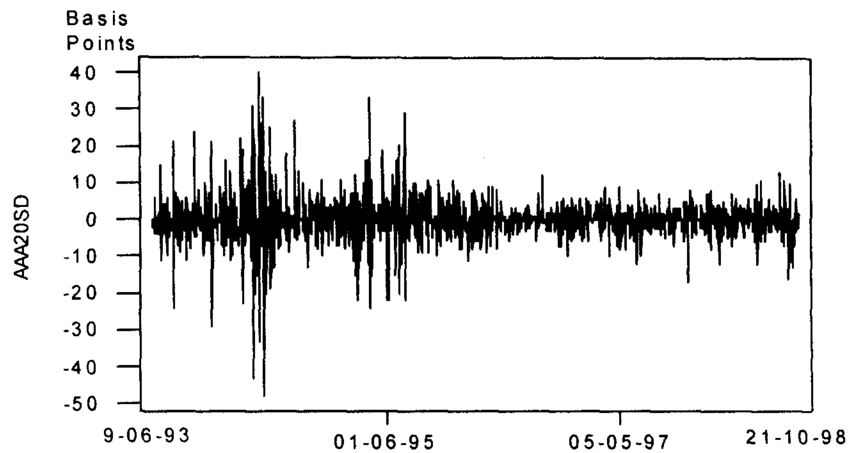
The final column displays the result of a normality test (Anderson-Darling Chi-Squared based test) which suggests that at a > 0.000 there is evidence that all the return series do not follow a normal distribution, though all series are not equally non-normal with the shorter (2 and 3 year) and longer maturity (20 year) bonds having higher test scores than the more liquid 5, 7 and 10 year maturities. It is also interesting that the illiquid shorter and longer maturities also have more observations outside the 98% and 99% confidence interval than bonds with 5 to 10 year maturities. It would appear that the degree of liquidity in the underlying secondary market may be affecting the return behaviour.

The arithmetic return (measured in basis points) over the sample period provides evidence on the potential economic returns over the sample period. If returns follow a zero sum game then the long term returns should be zero. With the exception of the AAA20 spread return (11 basis points) all the series generated slightly negative but not significant economic returns. Collectively these results suggest the credit spread return series are not random and therefore that the market is not weak form efficient.

Figure 3 clearly shows the time varying nature of the daily credit spread return (first differences) between the credit spread on the 20 year AAA rated bond and the equivalent 20 year Japanese Government security for the period from 9 June 1993 to 21 October 1998. The spread return is measured in basis points. During the sample period there were three distinct periods of return volatility. The first two clusters centred around August 1994 and June 1995. This second period was a period of extensive central bank intervention. This second cluster was later followed by a period

Figure 3 Daily Return (First Difference) of the AAA Rated 20 Year Yen Denominated Eurobond Spread to 20 Year Japanese Government Security 9 June 1993 to 21 October 1998

This figure shows the time varying nature of the daily credit spread return (first differences) between the credit spread on the 20 year AAA rated bond and the equivalent 20 year Japanese Government security for the period from 9 June 1993 to 21 October 1998. The spread return is measured in basis points



of low and stable interday returns (commencing in January 1997). The period from January 1998 was also a period with high levels of currency volatility though this was not correlated with high levels of spread return volatility. Volatility transmission expressed in terms of the returns on asset markets is an area that requires further analysis.

An objective of this paper is also to understand the return generating process of the return series. We first determine the autocorrelation and partial autocorrelation structures of the various series, and test for stationarity. The first differences (returns) series were tested for autocorrelation and partial autocorrelations up to 940 lags with the autocorrelations for lags 1, 2, 3, 5, and 22 reported in Table 4. Then the various credit spread series were tested for stationarity, and these results are reported in Table 5.

(c) Tests for Autocorrelation and Stationarity

Table 3 Statistical Tests of the Returns (First Differences) in Daily Credit Spreads Between Different Ratings and Maturities of Yen Denominated Eurobond and the Equivalent Maturity Japanese Government Security 9 June 1993 to 21 October 1998

This table provides descriptive statistics (four moments) of the first differences (daily returns) in the credit spreads between Yen denominated Eurobonds with AAA and AA ratings and maturities of 2, 3, 5, 7, 10 and 20 years and the equivalent Japanese Government security. Also provided is the two tailed z-statistic where $H_0: \mu = 0$, versus $H_1: \mu \neq 0$, the number of observations outside the 99% and 98% confidence intervals, the sum of the return series and the Anderson-Darling normality test.

Credit Spread Return N=1382	Mean (basis points)	z-statistic (p-value)	Runs Test Observed (Expected)* 99.9%	Standard Deviation (basis points)	Skewness	Excess kurtosis	Observations outside confidence interval		Sum of return over sample period	Anderson Darling Normality test
							98%(+)	99%(+)		
AAA2	-0.028	-0.19 (0.85)	715 (665.2)*	5.388	0.173	11.503	4 (3)	2 (1)	-39	41.515 p=0.000
AAA3	-0.029	-0.20 (0.84)	745 (665.6)*	5.416	0.261	7.427	3 (3)	0	-40	36.005 p=0.000
AAA5	-0.032	-0.21 (0.84)	761 (662.4)*	5.699	-0.046	5.362	1 (1)	0	-44	30.722 p=0.000
AAA7	-0.027	-0.16 (0.88)	773 (669.4)*	6.373	-0.017	5.992	0	0	-37	31.896 p=0.000
AAA10	-0.010	-0.07 (0.95)	750 (661.6)*	5.715	-0.022	6.113	1 (1)	0	-14	31.695 p=0.000
AAA20	0.008	0.05 (0.96)	746 (663.6)*	5.994	-0.015	11.441	3 (1)	2 (0)	11	55.772 p=0.000
AA2	-0.049	-0.32 (0.75)	743 (664.8)*	5.676	-0.021	11.094	2 (2)	1 (1)	-68	52.498 p=0.000
AA3	-0.059	-0.39 (0.69)	765 (664.8)*	5.599	-0.017	6.622	2 (2)	1 (1)	-82	35.095 p=0.000
AA5	-0.046	-0.30 (0.77)	745 (672.9)*	5.734	-0.015	4.791	0	0	-63	26.166 p=0.000
AA7	-0.034	-0.20 (0.84)	777 (672.9)*	6.207	-0.010	5.846	2 (2)	0	-47	29.623 p=0.000
AA10	-0.027	-0.18 (0.86)	786 (661.2)*	5.837	0.152	9.297	2 (2)	1 (1)	-38	36.603 p=0.000
AA20	-0.052	-0.32 (0.75)	725 (648.2)*	6.108	-0.010	11.84	3(2)	2 (1)	-72	52.498 p = 0.000

Table 4 Correlations of the Statistical Tests of the Returns (First Differences) in Daily Credit Spreads Between Different Ratings and Maturities of Yen Denominated Eurobond and the Equivalent Maturity Japanese Government Security 9 June 1993 to 21 October 1998

This table records the Pearson product moment correlation coefficient between each pair of variables in the table. The variables are the daily credit spreads returns on AAA and AA Yen denominated Eurobonds calculated as first differences with 2, 5, 7, and 10 year maturities. The table also notes the p-values for the individual hypothesis tests of the correlations being zero below the actual correlations.

N = 1382	AA2	AA3	AA5	AA7	AA10	AA20	AAA2	AAA3	AAA5	AAA7	AAA10
AA3	.712										
p-value	0.000										
AA5	.556	.667									
p-value	0.000	0.000									
AA7	.514	.575	.733								
p-value	0.000	0.000	0.000								
AA10	.445	.527	.555	.605							
p-value	0.000	0.000	0.000	0.000							
AA20	.317	.378	0.466	.569	.569						
p-value	0.000	0.000	0.000	0.000	0.000						
AAA2	.835	.601	.552	.543	.415	.339					
p-value	0.000	0.000	0.000	0.000	0.000	0.000					
AAA3	0.619	.866	.632	.602	.507	.387	.664				
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000				
AAA5	0.095	.159	.260	.219	.075	.084	.114	.208			
p-value	0.000	0.000	0.000	0.000	0.005	0.002	0.000	0.000			
AAA7	0.459	.581	.706	.887	.563	.559	.524	.638	.235		
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
AAA10	.466	.488	.563	.632	.811	0.466	.492	.528	0.120	.615	
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
AAA20	.284	.332	.442	.540	.463	.827	.348	.377	.077	.554	.498
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

The autocorrelations for the various series showed the presence of significant negative autocorrelation and partial autocorrelation (not presented) in its short-term lag structure with significant t-statistics and Ljung Box Q statistics (LBQ) for all spread series at lags 1, 2 and occasionally 3 (e.g. AAA 2 spreads were negatively autocorrelated at lag 1 (-0.27) and at lag 2 (-0.09). This result is consistent with the earlier results for the runs tests and collectively suggest the return series are neither random process nor the markets weak-form efficient. The p-value of the LBQ statistic for all series and for all lags, fail to reject the null hypothesis that the autocorrelations for the first 66 lags equal zero.

Test results for the presence of unit roots in the daily yields, levels of the daily credit spreads and the first differences of the levels respectively are presented in Table 6 These tests are conducted using the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) procedures, where the values in parenthesis in the table represent the number of lags employed. Acceptance of the null hypothesis that the daily yields contain a unit root will indicate non-stationarity in the yield series. Rejection of the unit root null for the levels of the daily credit spreads and the first differences of the levels will indicate that the series under observation is either strictly stationary, or stationary around a deterministic trend. One implication of the presence of a unit root is that part of the effect of an unanticipated change in the levels of a time-series may be permanent (Van De Gucht et al. 1996).

Tests results at the 0.01 level in Table 5 using the unrestricted DF and ADF models (i.e. including a drift term and time trend) accept the unit root null for all of the daily yields series. Stationarity tests on the levels and first differences of the daily credit spreads rejected the unit root null for all the series at the 0.001. The results show that while the daily yields for all series were non-stationary, the levels and first differences of credit spreads for all series were stationary.

Ⅳ. Conclusion

The objective of this paper was to investigate the time-series behaviour and efficiency of the credit spreads between AAA and AA rated yen denominated Eurobonds and the equivalent maturity Japanese Government security. The results of this investigation are important for portfolio and risk managers, and particularly for traders of credit spread derivatives. A key determinate in the pricing of these instruments is the yield spread between a specified risk class of asset and the same maturity riskless government security. Understanding the distributional qualities of these spreads, the underlying processes and the efficiencies of spread markets is essential.

This contribution focused on the distributional nature of Yen denominated credit

Table 5 Autocorrelations of the Returns (First Differences) in Daily Credit Spreads Between Different Ratings and Maturities of Yen Denominated Eurobond and the Equivalent Maturity Japanese Government Security 9 June 1993 to 21 October 1998

The table presents the autocorrelations of the interday returns for each of the credit spreads for maturities of 2, 5, 7, and 10 years. The various time series were tested for autocorrelation up to 940 lags with the lags for 1, 2, 3, 4, 5, 12 and 22 reported in the table. The table also records the t-statistic associated with each autocorrelation and the Ljung-Box Q statistic (LBQ). The p-value of the LBQ statistic for all series and all lags fail to reject the null hypothesis that autocorrelations of the first 66 lags equal zero. The t-statistics suggest the series are all autocorrelated at least to lag 2

	AAA2	AAA3	AAA5	AAA7	AAA10	AAA20	AA2	AA3	AA5	AA7	AA10	AA20
Lag 1	-0.27	-0.30	-0.31	-0.31	-0.32	-0.21	-0.22	-0.29	-0.31	-0.32	-0.28	-0.21
T statistic	-10.03	-11.32	-11.56	-11.37	-11.94	-7.99	-8.24	-10.80	-11.39	-11.88	-10.37	-7.91
LBQ	100.90	128.46	133.89	129.50	142.97	63.99	68.01	116.94	130.13	141.47	107.76	62.74
Lag 2	-0.09	-0.05	-0.08	-0.11	-0.08	-0.09	-0.12	-0.01	-0.06	-0.08	-0.06	-0.11
T statistic	-3.10	-1.62	-2.59	-3.78	-2.67	-3.20	-4.17	-0.47	-2.17	-2.76	-1.93	-3.76
LBQ	111.92	131.58	141.91	146.49	151.63	75.22	87.17	117.20	135.72	150.69	112.06	78.21
Lag 3	-0.06	0.01	-0.06	-0.03	-0.06	0.05	-0.05	-0.01	-0.05	-0.01	-0.03	0.04
T statistic	-2.02	0.21	-1.88	-0.97	-1.87	1.81	-1.78	-0.33	-1.72	-0.47	-1.19	1.24
LBQ	116.69	131.63	146.18	147.90	155.91	78.84	90.73	117.33	139.26	150.96	113.72	79.94
Lag 5	0.01	0.02	-0.03	-0.06	-0.09	-0.09	0.02	0.00	-0.05	-0.09	-0.05	0.04
T statistic	0.38	0.51	-1.04	-1.93	-2.90	-3.16	0.53	-0.15	-1.62	-2.92	-1.75	1.24
LBQ	116.91	153.65	147.49	152.44	171.81	90.42	91.05	130.01	142.43	161.44	117.78	79.94
Lag 22	-0.01	0.02	-0.02	-0.01	-0.05	-0.02	-0.03	-0.04	-0.06	-0.03	-0.04	-0.01
T statistic	-0.23	0.53	-0.55	-0.21	-1.67	-0.84	-1.02	-1.32	-1.87	-0.84	-1.36	-0.46
LBQ	177.04	176.59	164.89	172.13	223.41	128.56	142.78	166.11	166.00	196.78	151.28	124.45
Lag 66	-0.05	-0.06	-0.03	0.00	-0.01	-0.04	-0.07	-0.08	-0.02	-0.08	-0.03	-0.04
T statistic	-1.49	-1.78	-0.85	-0.08	-0.39	-1.14	-2.06	-2.56	-0.68	-2.58	-0.92	-1.43
LBQ	340.41	241.51	244.90	239.83	315.64	229.71	277.71	242.60	240.68	292.41	213.94	211.66

Table 6 Stationarity Tests of the Daily Yields, Levels, and First Differences in the Credit Spreads Between Different Ratings and Maturities of Yen Denominated Eurobond and the Equivalent Maturity Japanese Government Security 9 June 1993 to 21 October 1998

The table presents the tests for mean stationarity in the daily yields, credit spread levels (*S*) and first differences of the levels (*SD*) respectively for AA and AAA rated Yen denominated Eurobonds. The table shows the results from the unrestricted Augmented Dickey-Fuller (ADF) test at lags of 7 and 23, and the unrestricted Dickey-Fuller (DF) test at lag = 0. Critical values for the ADF and DF tests at the 1% and 5% levels are -3.96 and -3.41 respectively.

	JPYAA				JPYAAA		
	DF (0)	ADF (7)	ADF (23)		DF (0)	ADF (7)	ADF (23)
AA2	-1.947	-1.856	-2.186	AAA2	-1.775	-1.918	-2.162
AA2S	-10.859	-5.964	-5.034	AAA2S	-11.873	-5.799	-4.343
AA2SD	-46.450	-16.596	-10.236	AAA2SD	-48.942	-16.593	-10.821
AA3	-1.986	-1.965	-2.327	AAA3	-1.739	-2.013	-2.299
AA3S	-11.054	-5.528	-4.350	AAA3S	-11.891	-5.157	-3.116
AA3SD	-50.073	-17.748	-10.967	AAA3SD	-50.860	-17.383	-11.311
AA5	-2.062	-2.136	-2.461	AAA5	-1.984	-2.122	-2.467
AA5S	-9.276	-3.570	-2.173	AAA5S	-8.864	-3.241	-2.249
AA5SD	-50.918	-18.742	-11.210	AAA5SD	-51.174	-19.156	-10.437
AA7	-2.244	-2.125	-2.453	AAA7	-2.249	-2.195	-2.496
AA7S	-9.359	-3.590	-2.777	AAA7S	-9.741	-3.668	-2.774
AA7SD	-51.662	-17.476	-9.078	AAA7SD	-50.931	-18.447	-9.599
AA10	-2.575	-2.001	-2.632	AAA10	-2.124	-1.764	-2.374
AA10S	-10.695	-5.032	-4.706	AAA10S	-12.705	-5.155	-3.175
AA10SD	-49.375	-17.269	-9.243	AAA10SD	-51.731	-17.195	-9.835
AA20	-2.271	-2.513	-3.388	AAA20	-1.922	-2.337	-2.939
AA20S	-6.165	-3.335	-3.836	AAA20S	-6.278	-3.816	-3.431
AA20SD	-46.583	-15.049	-7.354	AAA20SD	-46.279	-14.999	-8.470

spreads and highlighted issues of concern for the pricing of these instruments.

We found evidence of a time varying credit term structure and co-movement in credit spreads by maturity. These areas in particular require further analysis given the uncertain empirical outcomes identified in the U.S. corporate bond markets by Helwege and Turner (1999) and Fons (1990). Yen Eurobonds also display time varying, leptokurtic, and autocorrelated return behaviour, which is not consistent with the processes being random walks, or with the markets which trade the spreads being weak-form efficient. However these results were inconsistent across the different maturities and credit-classes of yen Eurobonds which may be a liquidity induced factor-generally the more liquid bonds displayed less volatility and the returns were more normal than illiquid bonds.

These results have important pricing implications for any option embedded in a credit derivative, and in particular options on credit spreads. Many statistical issues warrant further investigation, in addition to regulatory concerns, and there are also matters of pricing and portfolio risk management, which require resolution.

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