Corporate Credit Spreads: A cointegration approach and liquidity risk measures

Thesis by

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CONTENTS

ABSTRACT

Previous credit spread models examined the relationship among credit spread changes, default, and liquidity risk factors. However, given the nature of the Japanese credit market, it might take time for bond prices to reflect its fundamentals. Employing cointegration techniques, I found that the long-term factor also affects the credit spread.

Keywords: Credit Spreads; Cointegration; Error Correction; Unit Root; Liquidity

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1. Introduction

The difference between the yields on corporate bonds and those on government bonds (hereafter the "credit spread") can be classified into two broad categories, default risk and others. So-called structural models, as represented by Merton (1974), formulate firm value and amount of assets/debts outstanding, thus enabling us to measure the theoretical value of default risk premium.
Studies, including Collin-Dufresne et al. (2001), generally supported the validity of structural models, but they also indicated that default risk premium calculated from structural models cannot fully explain credit spreads. Delianedis and Geske (2001) pointed out that credit spreads are strongly impacted by market movements (such as taxes, jumps, liquidity, and many other market risk factors) which cannot be complemented by default risk premium.

In the Japanese bond market, the majority of investors rely on the 'buy and hold' or passive/semi-passive type of investment strategy. In addition, due to the immature repurchase market, it is difficult for Japanese corporate bond investors to take a naked short selling position. As seen above, the Japanese corporate bond market is far from being a perfect market, which is an important assumption in the asset pricing model. If there is a one-time shock, one can reasonably assume that it will take time for corporate bond prices to go back to reflect the market's fundamental values. Considering these features, I believe that the corporate bond credit spread is affected by some long-term variable factors, in addition to short-time variable factors which have already been researched in depth via the traditional credit spread model. In this paper, I focus on the long-term dynamics of the corporate bond spread and analyze it using cointegration.

Barnhill et al. (2000) examined the long- and short-term dynamics of yields on non-investment grade indices. Utilizing cointegration techniques, they concluded that the traditional yield spread model which focuses on the short-term dynamics of the market is not sufficient. They found that non-investment grade yields, Treasury yields, and Moody's default rates were cointegrated, and developed analysis using the vector error correction model which added an error correction term, the long-term variable factor.

Ou (2011) focused on proxies for liquidity of the Japanese corporate bond market and was able to measure liquidity, price liquidity and credit risk, and apply such to risk management through using the difference between the highest and lowest values of corporate bond spreads (High-Low Gap, HLG) reported by multiple market makers during January 2004 to August 2010. Miyakawa and Watanabe (2012) focused on the multifaceted nature of liquidity[1] of Japanese corporate bonds and

[1] BIS (1999) categorizes the multifaceted nature of market liquidity into three possible dimensions: tightness, depth, and resiliency. Omura et al (1998) also defines market liquidity in four dimensions: bid-offer spread, depth, speed

applied several liquidity measures simultaneously. Firstly they confirmed the importance of GAP (which represents the trading cost of corporate bonds, measured by a similar method as HLG) in explaining corporate bond spread by adding it to the multi-factor model that uses general independent variables such as price of equity, slope of the Japanese government bond, and Tibor-JGB spread. After that, it employs a dynamic panel estimation to simultaneously examine static price dispersion measured by GAP and the dynamic resiliency factor substituted by a lagged dependent variable. They found that in addition to GAP, the lagged dependent variable is statistically significant in explaining the corporate bond spread.

As seen above, studies into the liquidity of Japanese corporate bonds have been pursued broadly and in depth. To the best of my knowledge, however, there is no study which focuses on the long-term variable factors of Japanese corporate bonds. It is, therefore, meaningful to study long-term variable factors using cointegration in order to better analyze factors influencing the Japanese corporate bond market. To this end, I firstly test traditional OLS with two liquidity factors—HLG as a proxy of tightness and lagged dependent variables (AutoRegression , AR) as a proxy of resiliency—to capture the multidimensional characteristics of the liquidity of Japanese corporate bonds. I implemented a cointegration approach and added a long-term variable (error correction term), then confirmed if there was any improvement in its explanatory power and also fitness of the model.

The rest of my paper is organized as follows: section 2 — introduction of the data I used for analysis, section 3 — explanation of the idea of unit root and cointegration, section 4 — consideration of the credit spread of A-rated corporate bonds[2] using regression analysis with multidimensional liquidity factors and error correction models, and section 5 — conclusion.

2. Data for Analysis

The data I used was aggregate monthly data of medium-term (3-7 years tenor) Japanese corporate bonds from Daiwa Bond Index (DBI), issued by Daiwa Institute of Research Holdings Ltd., from January 2003 to December 2012.

"HLG" is the difference between the highest and lowest values of corporate bond yields reported by multiple market makers as of each month-end. This HLG calculation includes data on more than 200,000,000 corporate bonds. Highest ratings among R&I, JCR, MDY, and S&P are used for the

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of price adjustment, and speed of trade execution.

[2]This paper reports the result of A-rated bonds, but a similar conclusion was achieved for AA-rated corporate bonds as well. AAA- and BBB-rated bonds are excluded from my research as there are not enough issuers in those categories and they are susceptible to the spread movement of specific sectors/issuers.

purpose of classifying bonds by ratings. Semiannually compounded yields are also used. The electric power, consumer finance, and real estate investment trust sectors are excluded from the data—the electric power sector experienced a structural change following the Fukushima Daiichi Nuclear Power Plant disaster; the consumer finance sector has also experienced a structural change, namely *kabarai kenkan* (the refunding of overcharged interest); and, a real estate investment trust is a vehicle which does not accumulate profit earned from the business, and thus does not fit into this study.

Other data, such as regarding equities, Japanese government bonds, FX, swap spreads, JPY interest rate swaption, implied volatility, and the sales forecast DI of small businesses are sourced from Bloomberg. All data used in my study is as of each month- end. Table 1 summarizes the data used.

TABLE 1:
DATA STATISTICS

Description	Short Name		Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
Nikkei stock average (Logarithmic format)	LNNKY	(yen)	9.33	9.28	9.81	8.93	0.24	0.51	2.04
Sales forecast DI of small and medium businesses	SMEDI	-	4.13	7.30	26.10	-42.90	12.51	-1.45	5.59
USDJPY (Logarithmic format)	LNJPY	(yen)	4.61	4.66	4.81	4.33	0.15	-0.45	1.75
Swap spread (5-year)	SS5y	(bp)	16.04	16.10	32.75	3.10	6.87	0.17	2.51
2-10 year Government bond spread	SLOPE	(%)	0.99	0.98	1.64	0.49	0.23	0.35	2.63
JPY interest rate swaption implied Vol.(Term 5y Tenor 5y)	VOL5y5y	-	30.12	29.50	46.80	21.90	5.24	0.73	3.37
Volatility index Japan	VXJ	-	25.49	23.63	91.45	13.59	10.23	3.26	18.43
2-year Govermnemt bond yield	JGB2	(%)	0.34	0.18	1.03	0.05	0.29	0.94	2.34
A-rated bond HLG	HLGA	(bp)	12.29	9.01	51.53	4.60	8.69	2.26	8.71
A-rated Daiwa Bond Index	ADBI	(bp)	45.12	36.16	136.85	19.72	28.07	1.86	5.79
Number of Monthly Obs.			119						

Source: Daiwa Bond Index, Japan Securities Dealers Association and Bloomberg

3. Unit Root Test and Cointegration

3.1 Unit Root Test

Much economic and financial data is non-stationary. The typical non-stationary process is a unit root process. When two or more time series data have unit root and if there is no cointegration relationship among them, a spurious regression problem occurs. In order to confirm the unit root, this study considers two unit root tests, an augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test. The results of the tests showed that all data except SS5y, SLOPE, and VXJ were found to be non-stationary, but the first difference of these non-stationary data was stationary with a 1% confidence level. The results suggested that all data except SS5y, SLOPE, and VXJ have a unit root. To avoid a potential spurious regression problem, this study utilizes a process in differences, except when there is a cointegration relationship among unit root data.

TABLE 2:
RESULTS OF UNIT ROOT TESTS

Level	ADF Test		PP Test	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
LNNKY	-1.509(0)	-2.059(0)	-1.734(5)	-2.171(4)
SMEDI	-2.272(0)	-2.758(0)	-2.365(1)	-2.908(2)
LNJPY	-0.907(0)	-1.929(0)	-0.888(4)	-1.983(2)
SS5y	-2.724(1)+	-2.589(1)	-2.973(4)*	-3.079(4)
SLOPE	-2.471(3)	-3.768(3)*	-2.07(1)	-2.784(2)
VOL5y5y	-2.18(0)	-2.294(0)	-1.944(2)	-1.916(7)
VXJ	-3.962(0)**	-3.992(0)*	-3.826(2)**	-3.861(2)*
JGB2	-1.289(0)	-1.348(0)	-1.425(2)	-1.348(0)
HLGA	-2.045(1)	-2.043(1)	-2.127(5)	-2.127(5)
ADBI	-1.81(1)	-2.096(1)	-1.767(7)	-2.047(7)
1% level	-3.487	-4.038	-3.487	-4.038
5% level	-2.886	-3.449	-2.886	-3.448
10% level	-2.580	-3.150	-2.580	-3.149

1st Difference	ADF Test		PP Test	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
LNNKY	-9.079(0)**	-9.042(0)**	-9.107(4)**	-9.107(4)**
SMEDI	-10.466(0)**	-10.424(0)**	-10.458(7)**	-10.458(7)**
LNJPY	-10.636(0)**	-10.728(0)**	-10.742(5)**	-10.742(5)**
SS5	-13.738(0)**	-13.685(0)**	-13.865(3)**	-13.865(3)**
SLOPE	-5.909(2)**	-5.882(2)**	-12.755(2)**	-12.755(2)**
VOL5y5y	-12.815(0)**	-12.759(0)**	-12.777(1)**	-12.777(1)**
VXJ	-10.576(1)**	10.534(1)**	-14.087(15)**	-14.087(15)**
JGB2	-9.874(0)**	-9.832(0)**	-9.825(1)**	-9.825(1)**
HLGA	-8.757(0)**	-8.727(0)**	-8.83(3)**	-8.83(3)**
ADBI	-5.183(0)**	-5.157(0)**	-5.267(5)**	-5.267(5)**
1% level	-2.585	-3.487	-2.585	-3.487
5% level	-1.944	-2.886	-1.944	-2.886
10% level	-1.615	-2.580	-1.615	-2.580

Note: ( ) in ADF test represents selected lag intervals based on SBIC, ( ) in PP test represents selected lag interval based on Newy-WestBandwidth automatic selection(Bartlett kernel)
Statistical Significance of **: 1%、*: 5%、+: 10% (based on MacKinnon,Haug and Michelis(1999))
Source: Daiwa Bond Index, Japan Securities Dealers Association and Bloomberg

3.2 Cointegration and Granger Representation Theorem

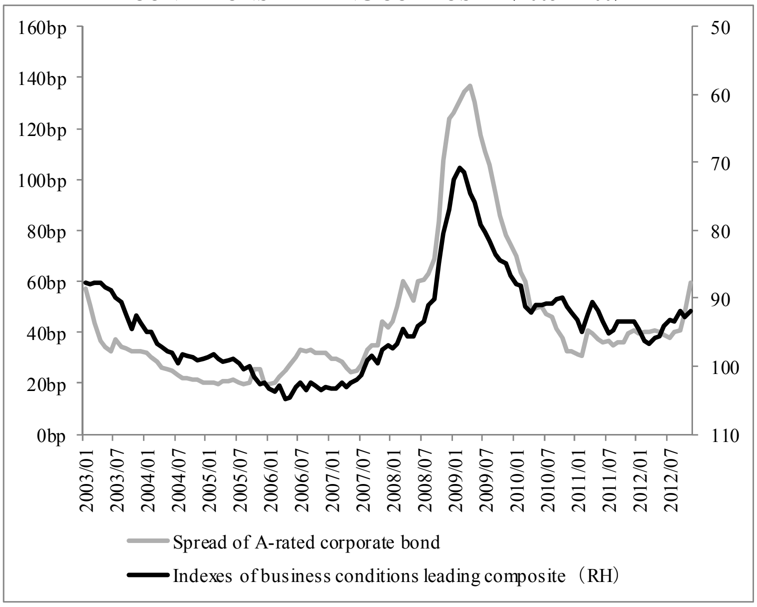
The traditional approach to handle non-stationary data is to model a process in differences. While this is a common practice to change non-stationary economic data to be stationary, it might cause the potential loss of information. Instead of directly moving to a model utilizing differences, an analysis needs be performed to first determine if there is a cointegration relationship between two or more unit root processes. Granger has showed that the AR process of cointegrated vector auto regression is expressed as a vector error correction (VEC) model which includes an error correction term (ECT). This is known as Granger's representation theorem, and it indicates that information contained in a level form plays an important role in explaining the movement of the differentiated unit root process. The vector error correction model is generally expressed as follows:

$$\Delta y_t = \zeta_1 \Delta y_{t-1} + \zeta_2 \Delta y_{t-2} + \cdots + \zeta_{p-1} \Delta y_{t-p+1} + \alpha + BA' y_{t-1} + \epsilon_t \qquad \ldots(1)$$

$\zeta_1, \cdots, \zeta_{p-1}$ are parameters. Vector A' is a cointegration vector and vector B represents speed of adjustment to disequilibrium. One big difference between the VEC and VAR model is that the former includes error correction term BA'yt-1, which represents a correction towards equilibrium by multiplying Ayt-1, the distance from the long-term equilibrium in period(t-1), and B, speed of adjustment toward equilibrium. Because of this effect, the VEC model is said to express a dynamic relationship including equilibrium. I then test if there is a cointegration relationship among corporate bond spreads and other economic variables.

Normally, the corporate bond credit ratings of rating agencies take into consideration the impact of the macroeconomic cycle. Having said that, the spread of corporate bonds averaged by ratings should not be that much affected by the macroeconomic cycle, but, in reality, the macroeconomic cycle does affect corporate bond spreads. Graph1 clearly shows that there is a strong relationship between corporate bond spread and the economic leading indicator. Given such a relationship, one can reasonably assume that there is a long-term relationship between corporate bond spreads and macroeconomic variables. Having performed cointegration tests to confirm if there is a cointegration relationship between corporate bond spreads and macroeconomic variables such as leading economic indicators, I found that the small and medium-sized corporation DI, Nikkei Stock Average, and A-rated corporate bond spreads are cointegrated (GRAPH 1)

GRAPH 1 :
SPREAD OF A-RATED CORPORATE BOND AND INDEX OF BUSINESS CONDITIONS LEADING COMPOSITE（2005＝100）



Sources: Daiwa Bond Index and Bloomberg

TABLE 3:
RESULT OF COINTEGRATION TEST

DBI	A-rated corporate bonds
Lags interval (in first differences): 1 to 1	
Null	**Hypothesized No. of CE(s) : 0**
λTrace	51.384
5% Critical value	35.193
P-value	0.000
λmax	38.737
5% Critical value	22.300
P-value	0.000
Null	**Hypothesized No. of CE(s): At most 1**
λTrace	12.647
5% Critical value	20.260
P-value	0.393
λmax	8.737
5% Critical value	15.892
P-value	0.463
Normalized cointegration coefficients	
Nikkei stock average (Logarithmic format)	-75.655
Std. Dev.	-17.562
Sales forecast DI of small and medium businesses	3.716
Std. Dev.	-0.351
Intercept	645.660
Std. Dev.	-163.022
Adjustment coefficients	-0.064
Std. Dev.	0.016
t-value	-3.896

Source: Daiwa Bond Index and Bloomberg

I also confirmed the stability of that relationship by performing rolling tests which analyze the consistency of the ECM coefficient estimate over time using recursive estimation. To do this the ECM variable is estimated using data for five years and the change in the coefficient is then tracked over time as each additional time period is added to the model. Johansen's maximum likelihood estimation is used for the estimation of coefficients as a cointegration relationship among three variables is considered. A detailed interpretation of this cointegration relationship is given in section 4.2

4. Analysis Using Models

In this section, I firstly apply OLS regression to ascertain how accurately it will explain the movement of corporate bond spreads. Secondly, I apply an error correction model which includes error correction term, a proxy for the long-term relationship, and determine if there is any improvement in the explanatory power of the model. Lastly, I interpret the meaning of error correction term.

Preceding studies, including Collin-Dufresne et al. (2001), use a linear regression model to explain the relation of corporate bond spreads and other variables, and I apply the same method in the first step. Explanatory variables used in my model are taken from previous corporate bond studies such as Collin-Dufresne et al. (2001), Oyama and Sugimoto (2007), and Nakamura (2009)[3].

TABLE 4:
INDEPENDENT VARIABLES (FIRST DIFFERENCE)

Independent Variables	Short Name	Facotr	Expected Sign
Nikkei stock average (Logarithmic format)	LNNKY	Economic	-
Sales forecast DI of small and medium businesses	SMEDI	Economic	-
USDJPY (Logarithmic format)	LNJPY	Economic	-
Swap spread (5-year)	SS5y	Economic	+
2-10 year Government bond spread	SLOPE	Economic	-
JPY Interest rate swaption implied vol.(Term 5y Tenor 5y)	VOL5y5y	Economic	+
Volatility index Japan	VXJ	Credit	+
2-year Govermnemt bond yield	JGB2	Credit	-
A-rated bond HLG	HLGA	Liquidity	+
A-rated Daiwa Bond Index	ADBI	Liquidity	+

Sources: Author

OLS Regression（A-rated corporate bonds, liquidity measures in bold）

$$\Delta(ADBI)_t = \gamma_1\Delta(LNNKY)_t + \delta_1\Delta(LNNKY)_{t-1} + \gamma_2\Delta(SMEDI)_t + \delta_2\Delta(SMEDI)_{t-1} + \gamma_3\Delta(LNJPY)_t + \delta_3\Delta(LNJPY)_{t-1} + \gamma_4\Delta(SS5y)_t + \delta_4\Delta(SS5y)_{t-1} + \gamma_5\Delta(SLOPE)_t + \delta_5\Delta(SLOPE)_{t-1} + \gamma_6\Delta(Vol5y5y)_t + \delta_6\Delta(VOL5y5y)_{t-1} + \gamma_7\Delta(VXJ)_t + \delta_7\Delta(VXJ)_{t-1} + \gamma_8\Delta(JGB2)_t + \delta_8\Delta(JGB2)_{t-1} + \boldsymbol{\gamma_9}\Delta(\boldsymbol{HLGA})_{\boldsymbol{t}} + \boldsymbol{\delta_9}\Delta(\boldsymbol{HLGA})_{\boldsymbol{t-1}} + \boldsymbol{\delta_{10}}\Delta(\boldsymbol{ADBI})_{\boldsymbol{t-1}} + \varepsilon_t \qquad \ldots(2)$$

4.1 A-rated Corporate Bond Spread

I firstly apply OLS regression without liquidity measures. The Akaike's Information Criterion (AIC) and explanatory power of that model (adjusted R squared) are 5.16 and 0.21 respectively. This result is broadly in line with the result of Collin-Dufresne et al. (2001) which suggests that OLS regression based on macro variables and variables used in the structural model only explains 25% of the

[3] Credit rating is a principal factor in the pricing of corporate bond spreads, and is already included in A-rated corporate bond data.

movement of corporate bond spreads. Secondly, I performed OLS regression with two liquidity measures. AIC and explanatory power are improved significantly to 5.333 and 0.587 respectively. This huge improvement in explanatory power is consistent with the result of previous studies. After reconfirming these results, I finally add the error correction term which represents the cointegration relationship that I found in section 3. By adding it, AIC and explanatory power are improved to 5.219 and 0.634 respectively (TABLE 5). As expected, by adding error correction term, the fitness of the model is improved.

TABLE 5:
RESULTS OF ERROR CORRECTION MODEL AND REGRESSION MODEL

		Error Correction Model (incl Liquidity Proxy)		Regresion Model (incl Liquidity Proxy)		
Variables	Lag	Coefficient	t-value	Coefficient	t-value	Factor
⊿ LNNKY	t	-19.864	-2.239	-18.133	-1.928	Economic
	t-1	5.571	0.635	6.317	0.678	Economic
⊿ SMEDI	t	0.023	0.378	0.106	1.738	Economic
	t-1	0.087	1.360	-0.023	-0.383	Economic
⊿ LNJPY	t	0.891	0.073	4.327	0.334	Economic
	t-1	9.668	0.800	14.714	1.154	Economic
⊿ SS5y	t	0.074	0.784	0.051	0.510	Economic
	t-1	-0.010	-0.114	-0.035	-0.385	Economic
⊿ SLOPE	t	1.467	0.394	1.634	0.417	Economic
	t-1	-1.622	-0.420	-1.046	-0.256	Economic
⊿ VOL5y5y	t	0.049	2.640	0.088	0.449	Economic
	t-1	-0.111	-0.556	-0.052	-0.244	Economic
⊿ VXJ	t	-0.068	-1.010	-0.026	-0.366	Credit
	t-1	0.252	4.059	0.271	4.131	Credit
⊿ JGB2	t	-9.750	-2.046	-9.473	-1.872	Credit
	t-1	6.042	1.279	7.607	1.522	Credit
⊿ HLGA	t	0.571	4.357	0.609	4.391	Liquidity
	t-1	-0.099	-0.688	-0.066	-0.430	Liquidity
⊿ ADBI	t	-	-	-	-	-
	t-1	0.490	5.731	0.567	6.439	Liquidity
Error correction term	t-1	**-0.068**	**-3.677**	-	-	**Cointegration**
Adjusted R squared		0.634		0.587		
AIC		5.219		5.333		
Std. Dev.		3.045		3.233		

*Error correction term:（ADBI＝-2.802*SMEDI+40.45*LNNKY-317.49）t-1
(t-value) (-1.624) (5.283) (1.372)
Sources: Author

By using selected variables based on AIC, I obtain the results as shown in Table 6. AIC and explanatory power are improved to 5.072 and 0.657 respectively. Among economic variables, as expected, the Nikkei Stock Average is found to have a statistically significant negative effect on A-rated corporate bond spreads. Among credit risk factors, also as expected, VIX Japan has a statistically 1% significant positive effect. Two-year JGBs have a statistically significant negative effect for time period t, but with a one-month lag a statistically 10% significant positive effect[4]. Two types of liquidity measures are statistically 1% significant, and have a positive effect as expected. The Jarque-Bera normality test suggests that residuals are normally distributed with 1% significance. The Ljung-Box test does not find a serial correlation.

TABLE 6:
RESULT OF ERROR CORRECTION MODEL（USING SELECTED VARIABLES BASED ON AIC）

Variables	Lag	Coefficient	Std. Dev.	t-value	Factor
⊿LNNKY	t	-13.091	5.260	-2.489	Economics
⊿SMEDI	t	0.030	0.058	0.526	Economics
	t-1	0.081	0.057	1.410	Economics
⊿VXJ	t-1	0.210	0.040	5.234	Credit
⊿JGB2	t	-9.041	4.422	-2.044	Credit
	t-1	6.873	4.414	1.557	Credit
⊿HLGA	t	0.552	0.119	4.640	Liquidity
⊿ADBI	t-1	0.448	0.066	6.751	Liquidity
Error correction term	t-1	-0.067	0.017	-3.861	Cointegration
Adjusted R Squared		0.657			
AIC		5.072			
Std.Error. of Equation		2.946			

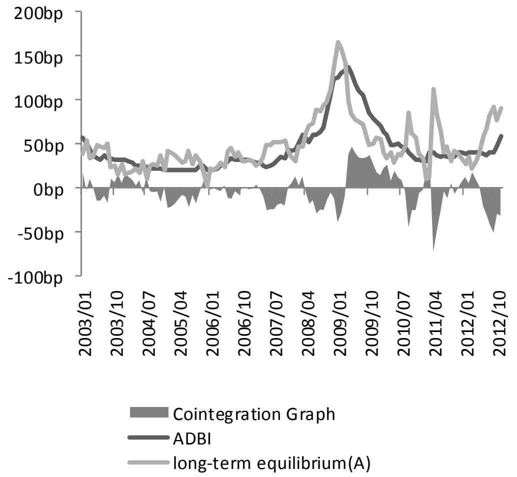
*Error correction term（ADBI＝-2.821*SMEDI+45.523*LNNKY-365.019）t-1
(t-value)　（-1.904）　（5.605）　（1.645）
Sources: Author

4.2. Interpretation of Error Correction Term

In section 4.1, I confirmed that the explanatory power and fitness of the model improve by adding error correction term. In this section, I interpret the cointegration relationship represented in the error correction term. As I explained in section 3, the error correction term captures the distance between current corporate bond spread and long-term equilibrium and the speed of convergence towards equilibrium. Graph 2 is a cointegration graph which represents the difference between corporate bond spread and equilibrium. By checking it, one can see that discrepancy appears in both positive and negative territory, and there is a tendency for discrepancy to converge in the long term.

[4]A negative sign for 2-year government bonds (Lag T) means that a rising government bond yield attracts purchase of corporate bonds in the short term, but positive sign for Lag T-1 means this attraction is short-lived and is partially reversed the following month. The sum of two coefficients is negative, which indicates that 2-year government bond yields and corporate spreads are negatively correlated.

GRAPH 2:
LONG-TERM EQUILIBRIUM AND A-RATED CORPORATE BOND SPREAD



Sources: Author

GRAPH 3:
COINTEGRATION GRAPH (INTEGRATED)

Sources: Author

The feedback coefficient in Table 6 was -0.067(=6.7%)[5], which indicates there is a convergence of disequilibrium towards equilibrium by 6.7% per month. In addition, having integrated the cointegration graph to ascertain the tendency of disequilibrium (whether positive or negative), corporate bond spreads stay in negative territory (=corporate bond spread tighter than its long-run equilibrium) except during the Great Recession period. I assume this tighter bias comes from the fact that many corporate bond investors adopt a "buy and hold" investment stance and that there is an inherent difficulty in taking short positions in the Japanese corporate bond market because of the immature repurchase market. On the other hand, it stayed in positive territory (=corporate bond spread wider than its long-run equilibrium) for a while after the Great Recession which I presume is because polarization of the corporate bond market due to the serious financial crisis and a series of defaults in the Japanese corporate bond market during that period[6] made it difficult for the market to reflect the sudden turnaround of macroeconomic fundamentals after the Great Recession.

In addition to the above, I examined the meaning of the signs of coefficients of the Nikkei Stock Average and small and medium-sized DI in the cointegration relationship (equation in levels) and in the main model (equation in differences). In the cointegration relationship, I see a negative sign for small and medium-sized DI and a positive sign for the Nikkei. In the main model, I see no statistically significant relationship between corporate bond spreads and SMEDI, and see a negative sign for the Nikkei. It is counterintuitive to have a positive sign for the Nikkei in a cointegration relationship because, in general, when a stock price goes up, the credit spread contracts; however, I

[5] By solving (1-0.067)^X=0.5, we gain X≒10, which means that the discrepancy tends to decrease by half in 10 months.

[6] Default events during this period: Suruga Corporation (Jun 2008), Zephyr (July 2008), Urban Corporation (Aug 2008), New City Residence (Oct 2008), The Japan General Estate (Feb 2009), Pacific Holdings (Mar 2009), Joint Corporation (May 2009), Japan Airlines (Jan 2010), and Takefuji (Oct 2010).

think this sign shows an interesting relationship between corporate bond spreads and the Nikkei in both the short and long term. In the short term, an equity index price such as the Nikkei is a reliable leading indicator of the macroeconomy and corporate performance, and, when it rises, corporate bond spreads contract. On the other hand, in the long term, as seen in section 3, aggregate corporate performance is an important factor in the movement of corporate bond spreads, and has a negative impact on them in the long term in some cases when the rise in equity prices is not the result of an improvement in corporate earnings[7]. This kind of equity performance makes corporate bond spreads contract in the short term, but will cause a discrepancy from long-term equilibrium, and, in the longer term, such discrepancy will be corrected through the error correction term.

5. Concluding Remarks

In this paper, I firstly examined corporate bond spread with multidimensional liquidity factors. After that, an error correction term (cointegration relationship) was added to compare if there was any improvement. Through this I concluded that by including error correction term, which represents the long-term relationship between corporate bond spreads and macroeconomic variables, explanatory power and fit of the model had improved.

Corporate bond spreads follow the unit root process and, to avoid spurious regression, the traditional approach is to model the process in differences. However, by differencing, there is a potential loss of information on the long-run interaction of variables. So, instead of directly moving to a model utilizing differences, I focused on the unit root of corporate bond spread and applied a cointegration technique to consider the long-term relationship through error correction term. My findings appear to highlight that in addition to short-term dynamics, long-term effects do affect Japanese corporate bond spreads.

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[7] Examples: Increasing financial leverage, increased asset volatility, asset price bubble.

References

Bank of International Settlements [1999], "Market Liquidity: Research Findings and Selected Policy Implications", *CGFS Publications* No 11.

Barnhill Jr., Theodore M., Frederick L. Joutz, and William F. Maxwell [2000], "Factors affecting the yields on noninvestment grade bond indices: a cointegration analysis", *Journal of Empirical Finance*, Vol. 7 (1), 57-86.

Collin-Dufresne, Pierre, Robert S. Goldstein, and J. Spencer Martin [2001], "The Determinants of Credit Spread Changes", *Journal of Finance* Vol. 56, 2177-2207.

Delianedis, G. and R. Geske, [2001], "The components of corporate credit spreads: Default, recovery, tax, jumps, liquidity, and market factors". Working paper, The Anderson School at UCLA. No. 22-01.

Granger, C. W. J. [1983], "Co-Integrated Variables and Error-Correcting Models", unpublished UCSD Discussion Paper 83-13.

Johansen, S., [1988], "Statistical Analysis of Cointegration Vectors", *Journal of Economic Dynamics and Control*, Vol. 12, No. 2–3, 231–254.

Johansen, S. [1991], "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models", *Econometrica*, Vol. 59, No. 6, 1551–1580.

MacKinnon, James G., Alfred A. Haug, and Leo Michelis [1999], "Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration", *Journal of Applied Econometrics*, Vol. 14, No. 5, 563–77.

Merton, Robert C. [1974], "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates", *Journal of Finance* 29, 449-470.

Miyakawa, D., and S. Watanabe [2012], "Pricing Illiquidity of Corporate Bonds through Static and Dynamic Measures", *Seoul Journal of Economics* 25 (3), 279-316.

Ou, K [2011], "Saiken no Sijou Ryudosei no Haaku to Kinyu Kikan no Risk Kanri eno Ouyou", *Bank of Japan Working Paper Series* No.11-J-2 (in Japanese).

Omura, K., J. Uno, H. Kawakita, and M. Toshino [1998], "Kabushiki Shijo no Maikuro Storakucha", *Nikkei Shinbun Sha* (in Japanese).

Sugimoto, T., and S. Ohyama [2007], "The determinants of credit spread changes in Japan", *Bank of Japan Working Paper Series* No.07-J-1 (in Japanese).

Nakamura, T. [2009], "Shasai Supured to Ryudousei Risuku ni Tsuite", *Securities Analysts Journal* 47 (3), 92-103 (in Japanese).