"Measuring the Effect of Liquidity on Corporate Bond Spreads: Evidence from Japanese Corporate Bond Data" [1]

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Miyakawa, D. [2] and S. Watanabe[3]
Development Bank of Japan and Gakushuin University

Abstract

This paper empirically studies the spreads of Japanese corporate bonds with putting a special emphasis on the quantitative impact of its illiquidity. While the extant studies for the liquidity risk on stock prices have been largely accumulated over the last ten years, its effect on bond spreads is still an open question. We find that (i) the explanation power is significantly improved by incorporating a noble proxy for the illiquidity of individual corporate bonds (GAP: highest minus lowest reported yields among market makers) to the standard static panel estimation of a multi-factor model, (ii) the impact of such an illiquidity measure on bond spreads becomes larger as credit ratings get worse, (iii) the GAP proxy is valid even after controlling the persistency on spreads, which has been considered as another proxy for illiquidity in the extant literature, through dynamic panel estimation, and (iv) the relative importance of the cross-section proxy (GAP) to the time-series proxy (persistency) for illiquidity decreases as the credit ratings of corporate bonds deteriorate. The last result implies the importance to appropriately incorporate the two proxies to study corporate bond spreads.

JEL Classification: G12, C23
Key words: Corporate Bond Spreads; Illiquidity Measure; Panel Estimation

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2 Corresponding Author, Associate Economist, Research Institute of Capital Formation, Development Bank of Japan, 1-9-3 Otemachi Chiyoda-ku, Tokyo, 100-0004 JAPAN. E-mail: damiyak@dbj.jp.
3 Special Visiting Professor, Faculty of Economics, Gakushuin University, 1-5-1 Mejiro Toshima-ku, 171-8588 JAPAN. E-mail: shuji.watanabe@gakushuin.ac.jp. Chief Economist, Research Institute of Capital Formation, Development Bank of Japan, 1-9-3 Otemachi Chiyoda-ku, Tokyo, 100-0004 JAPAN. E-mail: shwatan@dbj.jp.

1. Introduction and Motivation

During the past financial crisis including the recent episode triggered by "Lehman shock", we have observed drastic time-series variation on bond spreads[4]. The classic asset pricing model for bond spreads, which are focusing on the macro and individual credit risk factors, however, cannot fully explain such bumpy spread dynamics. This somewhat poor performance of the extant models is largely originated from the fundamental characteristics of the corporate bond market in most countries including Japan. Namely, (1) most of the investors rely on "buy & hold" type investment strategy and the transaction volume is usually limited and, reflecting this, (2) market making is not very active[5].

Under such illiquid market structure, it is not easy even for the professional market makers to find out "market clearing prices". As a result, the quote of market makers has some distribution with non-zero variance and the distribution seldom converges to one point. This reflects the divergence or heterogeneity on market maker's bond evaluation under such an illiquid market. Interestingly enough, we also observe that such a break-down of the price-searching mechanism tends to be accompanied with persistency on the quoted bond spread provided by each market maker. Presumably, the lack of appropriate reference prices persuades market makers to look back at their own past quotation, which is another good illustration of illiquid markets.

The central theme of this paper is to explicitly study these two features of corporate bond market, both of which potentially represent the degree of illiquidity. We quantify how (i) the spread dispersion among market makers and (ii) the persistency of spreads govern corporate bond spreads. The dispersion can be interpreted as the heterogeneity of forecasts provided by marker makers while we can consider the persistency as a consequence of the break-down of price mechanism, both of which are generated by an illiquid market environment. Considering the fact that we usually do not

[4] In this paper, we use "spread" to denote the yield difference between the targeted financial security (i.e., corporate bonds) and Japanese Government Bond (JGB).
[5] As far as we know, even the U.S. and Euro corporate bond markets do not have highly liquid secondary markets where we can occasionally observe actual trading prices. Recent initiatives in Asian countries promoting corporate bond markets further exemplify how the current environment in the Asian corporate bond markets are far behind the U.S. and Euro markets.

have a valid bid-ask spread data in corporate bond market, which is a widely used proxy for illiquidity in stock markets, it is one promising way to model the effect of illiquidity on bond spreads with taking into account those two other factors explicitly in our empirical model.

We analyze the data provided by Japan Securities Dealers Association (JSDA). Note that this data of market makers' reporting prices are just indication and no obligation of trade with those prices. In this sense, those prices are not market clearing prices. In other words, they are not the prices that equate supply and demand. In fact, what we analyze are market makers' best guess on the market clearing prices at best. Although the available data from JSDA is limited, we think the data should account to considerable extent for the illiquid structure of the market. The data contains several information such as the highest and lowest yields for each bond, which can be used to construct our "GAP" measure (= highest yield – lowest yield) for each bond, which can capture an important property of the quote distribution.

In order to see how this GAP measure is informative, Figure-1 depicts the share of firms staying under a certain level of GAP (i.e., equal to or smaller than 5, 10, 15, and 20bp) out of the total sample firms. For example, the share of firms showing GAP smaller than 5bp reached more than 80% in the second half of 2005 where the market condition was relatively good and the liquidity was presumably high. In contrast, there are several periods where such a share went below 10% (e.g., 2003, 2008-2009).

Our first guess is if the market is illiquid in the sense that it is not easy for the market makers to find out "market clearing prices", the GAP for a given corporate bond could be widened with reflecting such illiquidity. To illustrate, if the market environment is good and market makers could observe the actual transactions precisely, the GAP will shrink. We use this measure to proxy the illiquidity of individual corporate bonds[6]. Next, our second guess is about the time-series index of illiquidity. As in the extant studies (Hauweling et al. (2003) and Nakamura (2009)), we can infer the illiquidity of corporate

[6] It is natural to conjecture the positive correlation between the GAP measure and firm's credit worthiness. As we will demonstrate later, the panel estimation we employ in this paper is suitable to disentangle those two correlated effects.

bonds by checking whether the reported prices by market makers has persistency or some stickiness. If the market becomes highly illiquid and market makers have the difficulty to find the market clearing prices, the lesser portion of their quote depends on the rational reasons and we will observe the stronger persistency in their previous quotes. We integrate these two conjectures by applying dynamic panel estimation to our balanced panel data constructed from the JSDA data.

While the existence of the variation in illiquidity and its potential implication on pricing have been stipulating a series of studies taking into account several notions of liquidity, they tend to treated the bond spreads as market-clearing prices and apply the analytical framework mainly used for more liquid market such as stock markets or sovereign bond markets. The prices and spreads in corporate bond markets are, however, usually not actual trading prices but rather reported quotes by market makers[7]. The bid-ask spreads, which is widely used for studying the relationship between stock prices and liquidity, is somewhat useless in this sense since serious analysis of such bid-ask spreads is only valid when the quoted price represents the actual market clearing price or its closest proxy. The starting point of our paper is to recognize the spreads data as the evaluation of corporate bonds provided by market makers and study how market makers alter their conjecture about "market clearing prices" with considering the both (i) variation in the distribution of reported prices by other market makers and (ii) their own past quotes.

Through such an analysis, we also attempt to provide an empirical evidence of the so called "Flight-to-Liquidity" view. If the sensitivity of bond spreads with respect to illiquidity measure differs among different credit ratings, we might be able to interpret it as the reflection of the investor's attitude toward low credit quality. The study of corporate bond spreads also gives us a tip for understanding various other low liquid financial securities such as ABS, CDO, and securitized products[8]. Again, the central motivation of this paper is to understand the market maker's forecast for the

[7] Even the U.S. and Euro markets cannot provide the complete set of the actual transaction prices in daily base.
[8] It is highly difficult to directly observe the prices of so called "Level-3 assets" categorized by U.S. Financial Accounting Standard Boards and SEC.

"market-clearing prices". Shedding light on the price of those illiquid assets would be very useful to understand the financial markets that have been facing tremendous difficulty in objective evaluation.

This paper is structured as follows. Section 2 briefly surveys the related literature. As a starting point, section 3 goes over our analytical framework and exercises the hypothesis formulation. Then, section 4 describes the data, and section 5 shows the estimated results. Section 6 compares our empirical results with existing studies and discusses some technical issues. Section 7 concludes and presents future research questions.

2. Related Literature

In this section, we briefly survey the related literature to our study. In the long strand of asset pricing literature, there are three types of papers we need to consider. The first group is the theoretical studies for the relationship between illiquidity and asset prices. In the context of market microstructure, there are a few theoretical studies explicitly modeling the illiquidity risk considered in our paper. One example is Tychon and Vannetelbosch (2005), which develops a corporate bond valuation model containing both the credit risk and the liquidity/marketability risk. Their main idea is that the liquidity risk is a function of the heterogeneity of investors' valuations. When such heterogeneity is high, corporate bond investors are worried about the marketability of the bonds in their portfolio as they might not be able to find an appropriate counterpart to sell the bonds in future. Most of the theoretical models categorized as "inventory model" share the same perspective. Since our data is not precisely an actual transaction price, we cannot directly apply their theoretical implication to our empirical study. We believe, nonetheless, GAP measure briefly described in the previous section can be interpreted as the heterogeneity on the belief among market makers. Note that there exist other theoretical explanations for why illiquid financial securities need to be accompanied with higher premium from the stand point of investor's liquidity demand (e.g., Holmstrom and Tirole (2001)) or transaction cost (Acharya and Pedersen (2005))[9]. Instead of digging into such theoretical pricing foundation of liquidity risk, we intend to provide new empirical findings which can contribute to the development of those theoretical studies.

Papers in the second category are the ones performing a classic empirical analysis for corporate bond spreads. The key implication shared by the literature is the inability of macro and/or micro credit factors for the purpose of explaining the corporate bond spreads (e.g., Jarrow et al. (2000), Edwin et al. (2001), Huang and Huang (2003), Eom et al. (2004)). For example, Collin-Dufresne et al. (2001) confirms that credit risk factors cannot explain bond spreads by incorporating various aggregate variables (e.g., S&P 500 returns, the slope of sovereign bond yields, the sovereign yields etc.) into the estimation. This empirical finding is discussed in another form as "Credit Spread Puzzle". For example, the seminal work by Hull et al. (2004、2005) show that the default probability implied by the corporate bond yield in the secondary market is more than ten times that the default rate calculated from the historical data. They also point out that there exists a significant gap between corporate bond spread and CDS spread. It is our motivation to fill the gap between the puzzle and the extant studies.

These results naturally motivate the third strand of the related papers on the empirical analysis incorporating illiquidity factor. This literature starts from a trial to choose an appropriate proxy capturing market-level liquidity. Extant studies (Fleming (2003), Goldreich et al. (2005)) use the sovereign bond yield which is theoretically not affected by credit factor in order to evaluate the performance of various proxies. By considering those established proxies, several papers directly deal with corporate bond spreads with considering individual liquidity factor. Amihud (2002) is a pioneering paper for measuring illiquidity by introducing ILLIQ measure, which is computed as the average of daily variation in stock return[10][11]. Including this ILLIQ measure, Houweling et al.

[9] Liquidity Asset Pricing Model(LAPM) in Holmstrom and Tirole (2001) studies the endogenous determination of liquidity premium, which is treated as somewhat ad-hoc in the previous literature. Their main idea is (i) investor's optimal choice generates liquidity preference and (ii) corporate bond spreads are determined in a general equilibrium framework.

[10] Precisely speaking, the ILLIQ measure is computed as the absolute price change divided by trading volume for

(2005) comprehensively studies several illiquidity factors associated with individual company and portfolio to a standard multi-factor model and establishes the illiquidity premium by using the data in euro area. Our paper has a very close motivation to the last paper.

About Japanese corporate bond market, the existing studies are rather limited. First, in the recent paper, Hongo and Oyama (2010) studies the mechanism governing the corporate bond spreads through a model without liquidity factor. Second, the importance of liquidity factor is studied in Saito et al. (2001) and Hori et al. (2008) by explicitly focusing on Holmstrom and Tirole (2001) type liquidity demand. Shirasu and Yonezasa (2008) also challenges the same question by using Japanese corporate bond market data. Third, Nakamura (2009) employs two methods to quantify the illiquidity risk on bond spreads, which largely shares its motivation with our paper. One difference is on our novel proxy for bond illiquidity and the estimation strategy. We plan to mention Bao et al. (2008)

3. Analytical Framework

In this section, we briefly go over our analytical framework. Different from the typical time-series estimation for sorted hypothetical portfolios employed in the extant literature, we use panel estimation with using a balanced panel data of Japanese corporate bond spreads. The benefits of employing the panel estimation are twofold. First, it can fully extract both the time-series and cross-section properties of our firm-level data. By applying the panel estimation framework to such a data set, we can examine the potential determinants of individual corporate bond spreads precisely. Second, our dynamic panel estimation enables us to establish the empirical implication of our GAP measure with controlling the persistency in quoted bond spreads from each market maker. As we can see later, the persistency parameter itself can be interpreted as a measurement of

a given stock on a given day. Since this ratio is a very noisy measure on any day, in practice, it is averaged over all trading days in a month or year to get a monthly or annual liquidity estimate for the targeted stock.

[11] For pricing the illiquidity risk of stock prices, Acharya and Pedersen (2005) directly incorporates the "illiquidity transaction cost" notion to an otherwise standard CAPM structure and price the illiquidity risk explicitly. Although our paper does not have an explicit asset pricing formulation as theirs, the model structure is actually an extension of Fama and French (1993). In this sense, we follow to some extent a traditional factor model/CAPM structure.

illiquidity.

3-1. Model

Following the usual asset pricing literature, we start from a basic multi-factor model proposed, for example, in Fama and French (1993).

$$SP_{it} = \beta_1 + \beta_2 F_t + + \beta_3 L_t + \varepsilon_{it} \quad \ldots \text{Model-1}$$

Here, the dependent variable SP_{it} denotes the spread of firm i at time t. As an explanatory variable, F_t denotes the market index (e.g., stock market index, the growth rate of the index, and/or its historical volatility) at time t. In addition to these aggregate credit factors, we incorporate the market liquidity factor L_t, which can be proxied by, for example, trading volume of corporate bonds, the number and/or volume of newly issued corporate bonds, and/or Tibor - JGB spread. We attempt to confirm that each coefficient has an expected sign implied by the extant theoretical studies.

Next, we advance to an extended version of the basic multi-factor model by incorporating f_{it} denoting the individual firm-specific credit risk factor of firm- i at time t. Potential proxies are credit ratings and/or historical volatility of stock returns.

$$SP_{it} = \beta_1 + \beta_2 f_{it} + \beta_3 F_t + + \beta_4 L_t + \varepsilon_{it} \quad \ldots \text{Model-2}$$

The most important twist in this paper is to incorporate the individual liquidity proxy l_{it} to the extended multi-factor model above.

$$SP_{it} = \beta_1 + \beta_2 f_{it} + \beta_3 F_t + + \beta_4 L_t + \beta_5 l_{it} + \varepsilon_{it} \quad \ldots \text{Model-3}$$

This additional factor is the key object in our paper and proxied by "GAP", which denotes the highest minus lowest reported yields among market makers at time t [12]. Introducing this GAP measure is valid only if we take a view that the quoted spread is actually not an equilibrium price and it would be rather an evaluation or forecast (i.e., the guess at equilibrium price) of each market maker. Considering the fact that we cannot observe enough number of traded bond prices, the usual proxy for illiquidity in financial market (e.g., bid-ask spreads) looses its practical meaning[13]. This paper tries to extract some pricing implication of liquidity risk under such a market environment by focusing on the limited but informative data such as mean, median, maximum, and minimum of the reported prices from market makers. Although we can potentially use bid-ask spreads under a market environment with high liquidity, corporate bond markets do not satisfy such a criterion[14]. Evidently, we observe most of the corporate bonds other than issued by highly rated utility companies etc (e.g., electricity companies) maintain a significant GAP over our sample period[15]. This provides a simple consequence that the market is not in equilibrium at most of the time. Studying the illiquidity in such a market needs other notions of illiquidity (i.e., GAP and/or persistency), which often has been mixed up with the standard illiquidity measure (e.g., bid-ask spread) in the existing literature thus far. To summarize, our main concern is (i) how Model-3 is better than other two models, and (ii) if the sign of estimated coefficients is consistent with theoretical predictions.

From a technical point of view, we might need to control the level of the quoted yield itself as in the standard finance literature in order to appropriately incorporate such GAP variable. One way to do so is to simply include the level of either highest or lowest quoted spread as well as the GAP itself while constructing a so called "relative distance measure" in Houweling et al. (2003), which divides GAP by some appropriate level variable

[12] Precisely speaking, we use one-day lagged GAP in order to avoid the simultaneous bias problem.
[13] In fact, JSDA data we use contains almost no data for bid-ask spreads although they prepare the category for recording. It seems to be very natural not to contain those variables which are only valid under the existence of equilibrium prices.
[14] We think securitization markets all over the world do not satisfy this condition either, in particular, after the sub-prime shock.
[15] In Japan, utility companies in the electricity and gas industries etc (e.g., NTT, JR) have been keeping highest ratings from the institutional reason.

(e.g., concurrent JGB yield), can be another treatment. We employ the latter method as a robustness check for our results in the later section.

As we will demonstrate in the next sections, incorporating GAP measure into the standard panel estimation improves the model performance significantly. Unfortunately, we still have a problem originated from the property of illiquid markets. Figure-2 plots a fitted SP_{it} and ε_{it} obtained from a random-effect estimation of Model-3. An apparent feature is the systematic pattern of the residual. This distribution seems to imply (i) there are some omitted variables and/or (ii) our static model itself faces a misspecification problem. We conjecture that the persistency of the bond spreads is one of the sources generating this systematic bias. From the updating procedure of their reporting prices, it is plausible that market makers partly consider the reported price in the previous day. The persistency of the reported spreads can generate the systematic bias we observe in the estimated results in Model-3. Based on this conjecture, we extend the static panel estimation presented above to the two types of dynamic panel estimation. First model is the one exhibiting a serial correlation on the error term.

$$\begin{aligned} &SP_{it} = \beta_1 + \beta_2 f_{it} + \beta_3 F_t + +\beta_4 L_t + \beta_5 l_{it} + \varepsilon_{it} \\ &and \qquad\qquad\qquad\qquad\qquad \ldots \text{Model-4} \\ &\varepsilon_{it} = \rho\varepsilon_{it-1} + \eta_t \end{aligned}$$

This model corresponds to the environment where we have some omitted variables. Second dynamic model is the one using a lagged dependent variable as an explanatory variable.

$$SP_{it} = \gamma SP_{it-1} + \beta_1 + \beta_2 f_{it} + \beta_3 F_t + +\beta_4 L_t + \beta_5 l_{it} + \varepsilon_{it} \quad \ldots \text{Model-5}$$

As described above, this could replicate the following reporting procedure implemented by marker makers: (1) Check the price on the previous day, (2) add some adjustment with taking into account the concurrent covariates, and (3) report the prices.

Figure-3 and -4 plot the fitted spreads and the model residual for Model-4 and Model-5, respectively. We can confirm the clear improvement of the model performance. As Arellano (2003) proposes, the dynamic models with lagged dependent variables are suitable for the estimation of economic variables with adjustment costs and/or habit formation. The typical example is the capital investment and employment. In the current context of bond spreads reported by market makers, it is exemplified by the break-down of searching mechanism for equilibrium prices and the dependence of market maker's bond evaluation on the spreads reported in the previous day. We conjecture that the persistency of the quoted prices provided by each market maker is another index of illiquidity. Such a feature is somewhat out of the usual equilibrium theoretical pricing notion since equilibrium price in a frictionless world, which is exclusively governed by demand and supply, has no reason to depend on the previous prices. We find it informative to incorporate both the GAP measure and the persistency measure (i.e., the dynamic structure on the dependent variable) to our analysis.

3-2. Hypothesis Formulation

Based on the discussion in the previous subsection, we construct the hypotheses we verify in the following sections. First, we conjecture that the quoted spreads of corporate bond is positively correlated with its illiquidity, which is measured by the absolute dispersion of market maker's quote prices, even after controlling the market factor as well as its individual factors (e.g., credit ratings, the volatilities of stock returns etc.). Second, the impact of such an illiquidity factor onto bond spreads is expected to have conditionality on credit ratings, which is provided by the flight-to-liquidity view. Third, the GAP proxy is conjectured to be valid to measure the impact of illiquidity on the spreads even after controlling the persistency on spreads. Forth, we guess that the relative marginal impact of the price dispersion to the importance of the persistency on the reported prices has conditionality on firms' individual characteristics (e.g., credit ratings) and the market condition of liquidity that is represented by the GAP.

4. Data

The data is obtained from Japan Securities Dealers Association (JSDA). It contains the reference data about Japanese corporate bond markets. In particular, the quoted yield indicates the highest, lowest, mean, and median bond yields among all the yields reported by selected market makers ("member security firms") after cutting the outliers based on predetermined percentages[16][17]. The member security firms report the yield of each company's existing bonds for different maturities by 4:30 pm every day as if they are asked to price the 500 million yen of the bonds as of 3:00 pm. JSDA collects the data and release the four reference data (i.e., highest, lowest, mean, and median) on its website at 5:30 pm[18].

From this data, we pick up the median spread as our dependent variable. Since we use the difference between highest spread and lowest yields as GAP measure, the median is more preferable than mean since it is not affected by the highest and lowest spread from its arithmetic manner. We also use the 1-day lagged GAP measure in order to avoid the simultaneous bias. Table-1(1) shows the summary statistics of our explanatory variables with its definition and Table-1(2) summarizes the correlation. While we have almost 120 firms in our original sample, the number of groups (i.e., firms) is reduced to about 52 because of the maturity control we explained below. It is important to note that our sample still contains a large variation in the credit ratings and GAP measure[19]. The sample period is 82 months from July 2003 to April 2010. Although the original data covers bit longer time periods, we focus on such a period where we can always

16 The selected market makers are as follows: SMBC Friend, Okasan, Credit Swiss, Cosmo, Goldman Sachs, Citi Group, Shinsei, JP Morgan, Daiwa SMBC, Deutch, Tokai Tokyo, Nomura, BNP Paribas, Marusan, Mizuo, Mizuho Investors, Mitsubishi UFJ, Merril Rinch Japan, Morgan Stanley, UBS.

17 If reporting firms are 34 to 40, cut 6 firms from the highest and lowest respectively. The cutting criteria is as follows: 27 to 33 security firms report, cut 5 from the highest and lowest. 21 to 26 security firms report, cut 4 from the highest and lowest. 15 to 20 security firms report, cut 3 from the highest and lowest. 10 to 14 security firms report, cut 2 from the highest and lowest. 5 to 9 security firms report, cut 1 from the highest and lowest.

18 If the gap between the highest and lowest (yield) becomes more than 500bp, the data is not released.

19 The current sample is a highly balanced panel data. We are planning to incorporate the unused data with proper treatment for missing values.

observe the GAP measure. In other words, we consider monthly data for Japanese listed firms which maintain a certain number of issued bonds. This is mainly because we want to transform the spread data of each corporate bond with various maturities into specific spreads corresponding to maturities 3-year and 5-year, instead of using the raw data for corporate bond yields[20]. In order to control the heterogeneity in maturity, we use the information of multiple corporate bonds issued by each company. More specifically, the different bonds for a given company are used to construct an interpolated yield curve. Then, our targeted spreads corresponding to maturity 3-year and 5-year are taken out from the yield curve with considering the concurrent JGB yield curve[21]. Thanks to this operation, we do not need to control the maturity by including the maturities as explanatory variables. Figure-5(1) and Figure–5(2) show the resulting yield curves for Tokyo Electric Power Company (TEPCO) and Tobu Railway (TOBU). Considering the shape of time-series data constructed in this way (see Figure-6), we believe this interpolation does not generate any severe problems.

5. Estimation

5-1. Results

In this section, we implement the estimations proposed in the previous section. First, we apply pooled OLS estimation, fixed-effect estimation, and random-effect estimation methods to the static model constructed as in Model-1 to -3. The results are summarized in Table-2(1). The sensitivity analysis of each coefficient with respect to the credit ratings and/or market conditions is further demonstrated in Table-2(2).

Before proceeding to the results, we have one technical note to be discussed about the selection of estimation methodologies. For the static model, we mainly refer to the results obtained from the random-effect model. This is due to our understanding that we

[20] Most of the existing literature incorporates the maturities in the explanatory variables instead of adjusting the maturity prior to estimation. From the standard practical manner, the assumption in the extant empirical studies that the maturities have a linear relation with the spreads is too restrictive. Evidently, we almost always observe non-linear shaped spread curve in reality.

[21] We gave up to construct 10-year spreads since we do not have enough number of long-term corporate bond data. On the other hand, we do not contain 1-year spreads in our analysis simply because the bonds close to its maturity tend to exhibit irregular dynamics.

have enough number of variables characterizing each of the 52 firms. In particular, the credit ratings for each company mentioned below resemble its fixed-effect.

The coefficients of introduced covariates are as follows: First, higher Tibor - JGB spreads (T_JGBGAP), which represents the tightness in the short-term financial market, contributes to higher median spread. Second, the residual in the regression of the individual stock price volatility on that of Nikkei Index (e_HV), which corresponds to the volatility of individual firm's value after controlling the aggregate shock, has a positive effect on the corporate bond spreads. Third, the credit ratings of each company provided by R&I (RATE_RI), which covers the largest number of Japanese companies, has the same implication as e_HV.

About the GAP variable, we can establish a strong positive correlation between GAP and median spreads. One remarkable point is that the inclusion of the GAP measure significantly improves the R^2 of the model. We also find that the size of the GAP coefficients depends negatively on the credit ratings (i.e., as the credit ratings are better, the GAP coefficients are smaller[22]). The variation of the GAP coefficients with respect to market condition is somewhat ambiguous. We judge this reflects the higher persistency of the reported spreads under a bad market conditions.

Although it seems that we succeed on improving the model by using the GAP measure in static panel estimation, the residual plot of the model in Figure-1 tells us the existence of a considerable problem in our estimation. Apparently, it shows heteroskedasticity and implies a couple of interesting points[23]. The first component is the lower part of the residual plot (i.e., the spreads of firms with good credit and those of good market environment period), which seems to form the down-sloped concentration. The second component (i.e., the spreads of firms with weak credit or those of bad environment period) can be found in the upper scattered portion. Because of the omitted variables that could capture the behavior of the latter component, the static model generates a bunch of very large positive residuals over the high spread range. These outliers attract the

[22] We transform each rating into numbers.
[23] In particular, if we plot the residual not with respect to the fitted spread but with the time, it becomes further clear that the residual has serial auto-correlation (need to be shown).

regression line upward and make the former portion over-estimated. Before adding another explanatory variable in order to overcome this problem, we tested a model assuming the serial correlation of the disturbance term. This model seems to partially ease the above problem and resolve the problem of over-estimation (see Figure-3). Evidently, it can explain the behavior of the firms with good credit and good environment rather well. Unfortunately, this remedy still remains a problem - the upper scattered portion still exists. The ultimate solution seems to be the adoption of the lagged dependent variable (i.e., the lagged spread). Looking at this scattered graph in Figure-4, the problem stemmed from this omitted variable seems to be resolved satisfactorily[24].

Note that for these two analyses, the dynamic panel models proposed as Model-4 and -5 are estimated through the GMM estimation in Arellano and Bond (1991) and the maximum-likelihood estimation. While GMM does not depend on the initial observations of dependent variable, ML does[25]. The results summarized in Table-3 shows, however, that those two estimation methods lead to almost similar coefficients[26].

We can also confirm that the dynamic panel still provides similar results as in the static model[27]. One point to be noted for the models with lagged dependent variable is that the AR(1) coefficient is 0.86 to 0.88, which indicates a strong serial auto-correlation. Such evidence of an observed habit persistency of the reported bond spreads is successfully confirmed through our dynamic panel estimation.

Another interesting point is that GAP has a stronger explanatory power for the bonds with better grades relative to the AR(1) coefficient. Table-4 summarizes the spectrum of the GAP coefficient and the AR(1) coefficient for different levels of credit

[24] There still remain a very few outliers but we think this is no longer the big problem. It is not difficult for us to identify these outliers and tells that is the result of detection of window dressing. It is very easy to trim out these by setting a dummy variable.

[25] The default setting of STATA for MLE does assume that initial value is exogenously given and does assume nothing on its distribution. Although this naïve ML estimation works well, it is better for us to assume the more consistent distribution derived from the model. We recognize it is our future task to employ the MLE methods proposed in Anderson and Hsio (1982), Bhargava and Sargan (1983).

[26] There are large differences between the standard errors of the coefficients provided by the two methodologies. We need to be clear about the sources and the interpretation of this difference.

[27] As the coefficient of the slope of JGB yield curve calculated by the difference between 10-year JGB yield and 2-year JGB yield increases, the spreads decrease. This result is somewhat controversial if we consider the discussion in Fama and French (1993) where the slope index is treated as a risk or a sigh of boom. One interpretation of this result is that the higher 10-year JGB yield is accompanied with boom while the lower 2-year JGB yield is generated by easing monetary policy.

ratings and market environments. The purpose of this additional analysis is to see the combination in the GAP coefficient and AR(1) coefficient with respect to the characteristics of cross-section and time-series sample variation[28]. It is clear that we have the trade-off between those two proxies for liquidities and the relative importance of those two objects is conditional on credit ratings and/or market conditions. In the extant literature, some conditionality has been pointed out in stock market return (e.g., Watanabe and Watanabe (2008)) such that the pricing impact of liquidity risk is larger for the firms with lower credit ratings.[29] As far as we know, however, the conditionality of relative importance of two liquidity measures with respect to the variations of credit ratings and/or market conditions has never been analyzed.

In order to check the robustness of the result, Table-5 reports the revised regression results in Model-3 to -5 under an adjusted GAP measure, which is constructed to divide the GAP by the concurrent JGB yield. The results obtained in the previous estimations are all confirmed in this additional estimation.

5-2. Discussion

We have found the importance of considering two proxies of illiquidity. The first one corresponds to cross-section dispersion of quoted bond spreads while the second one captures time-series property of bond spreads. This finding gives us a source of discussion about what is the illiquidity of assets in the market without frequent trading.

$$y_{ht} = \gamma_0 + \sum_{i=1}^{m} \gamma_i z_{ih} + \alpha y_{ht-1} + \sum_{i=1}^{n} \beta \gamma_i x_{iht} + u_{ht}$$

$$y_{ht} = \sum_{k=0}^{\infty} \alpha^k [\gamma_0 + \sum_{i=1}^{m} \gamma_i z_{ih} + \sum_{i=1}^{n} \beta \gamma_i x_{iht-k} + u_{ht-k}]$$

[28] In order to split the sample, we use (i) whether the credit ratings at the beginning of sample period is better than or equal to 4 (i.e., AA-), or worse than or equal to 5 (A+), and (ii) whether the share of firms satisfying "GAP is equal to or smaller than 10bp" is greater than 75% (i.e., the market conditions is GOOD) or not (BAD market condition). Note that if firms in our sample do not have their credit ratings from R&I but from other rating agencies, we transform those ratings into hypothetical R&I ratings (e.g., AAA=1, AA+=2, and so on). This transformation is done by referring to the companies holding both the R&I ratings and the ratings provided by other agencies.

[29] Their analysis is based on the hypothetical portfolio as in the other extant studies and does not employ the panel estimation.

Note that the dynamic panel estimation with the lagged dependent variable can be expressed as in the manner of Bhargava and Sargan (1983): (Need to be revised in the consistent way with the currently employed notation). The original Model-5 captures the idea that the spread reported at t is determined by the spread in $t-1$ and the other concurrent covariates. The second expression above states that the determination process can be interpreted as the weighted average of the past covariates other than the lagged dependent variables. The fact that we obtain a AR(1) coefficient close to one implies that the effects of past covariates cannot fade away quickly.

6. Comparison with existing studies

- To be completed
- Hauweling et al., and Nakamura, how our results nest some of their findings

7. Concluding Remarks

This paper empirically studies the determinants of Japanese corporate bond spreads with putting a special emphasis on the quantitative impact of its illiquidity. We find that (i) the explanation power is significantly improved by incorporating a noble proxy for the illiquidity of individual corporate bonds (GAP: highest minus lowest reported yields among market makers) to the standard static panel estimation of a multi-factor model, (ii) the impact of such an illiquidity measure on bond spreads becomes larger as credit ratings get worse although the sensitivity of GAP coefficient with respect to market condition is somewhat ambiguous, (iii) the GAP proxy is valid even after controlling the persistency on spreads, which has been considered as another proxy for illiquidity in the extant literature, through dynamic panel estimation, and (iv) the relative importance of the cross-section proxy (GAP) to the time-series proxy (persistency) for illiquidity decreases as the credit ratings of corporate bonds deteriorate. The last result implies the importance to appropriately incorporate the two proxies to study corporate bond spreads. Our research complements the limited number of quantitative research about Japanese corporate bond market and give some implication for the markets associated with relatively low liquidity (e.g., ABS, CDO, and/or realty market)[30].

To conclude, we list several future research questions. First, the refinement of our dynamic panel estimation such as the proper selection of instrument variables and/or imposing an appropriate structure to the distribution of error term in MLE. Along this line, it would be interesting to construct a static measure representing the price stickiness (e.g., ILLIQ-type measure and/or the difference of GAP measure). Second, it is necessary to connect our estimated results with theoretical frameworks. Although some selected papers are constructing market microstructure model considering the heterogeneous view among market makers, they do not cover the individual persistency in the reported spreads by each market maker. What we need to construct is the model where market maker continuously revises its evaluation about bond spreads and still exhibits the heterogeneity of their evaluations. Toward this direction, it might be useful to consider, for example, the market maker's learning process in an explicit way. Through such a model, we can also study the distributional dynamics of market maker's reporting contents. Third, our analysis needs to be refined as in the consistent way with the CAPM literature with liquidity risk (e.g., Acharya and Pedersen (2005)). Fourth, it is important to incorporate the unused data in our original sample with a proper treatment for missing values. One idea is to apply Tobit-type framework to the original data while it would be another possibility to construct a market GAP and/or estimate the individual gap for the firms without reported spreads, hence GAP. Fifth, the determination of GAP and further empirical analysis of the distribution of reported spreads would be informative research objects. We believe all of these extensions provide further guides for better understanding of the bond markets and prices as well as securitized products in low liquid markets.

[30] Although the development of corporate bond markets in Japan is largely proposed, there seems to be no room for accepting such a propose in the current Japanese market.

<Table and Figure>

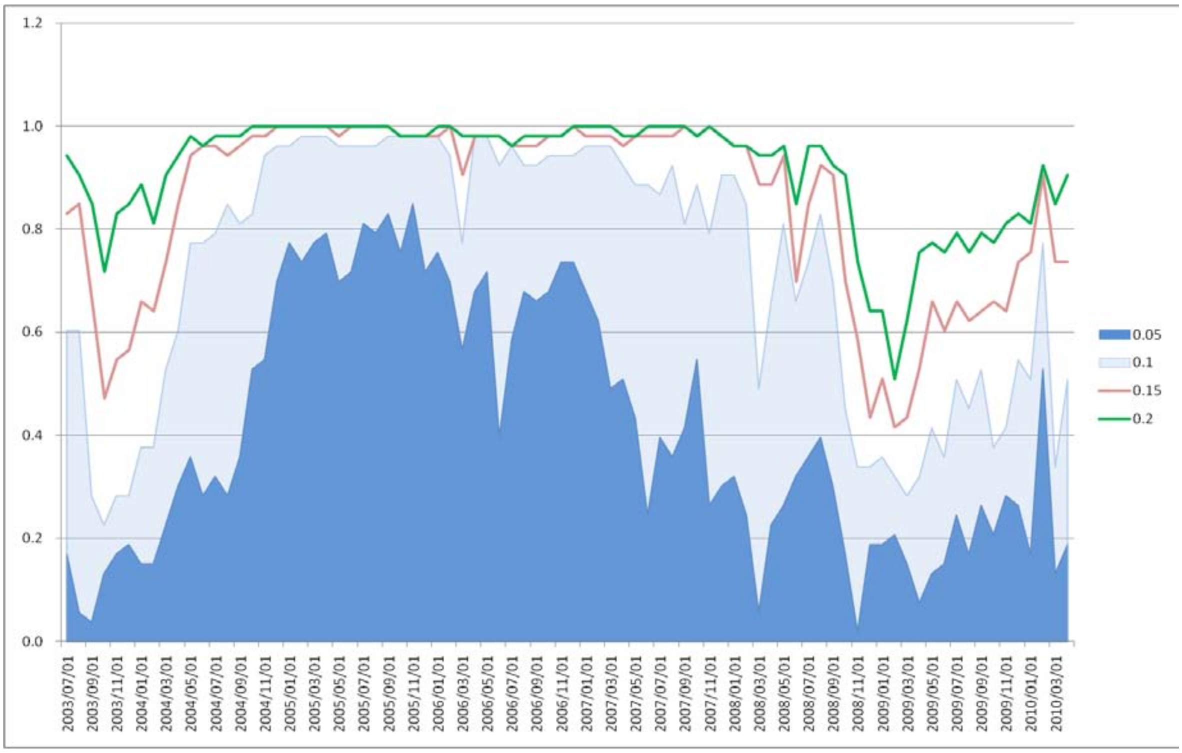

Figure-1: The distribution of GAP measure

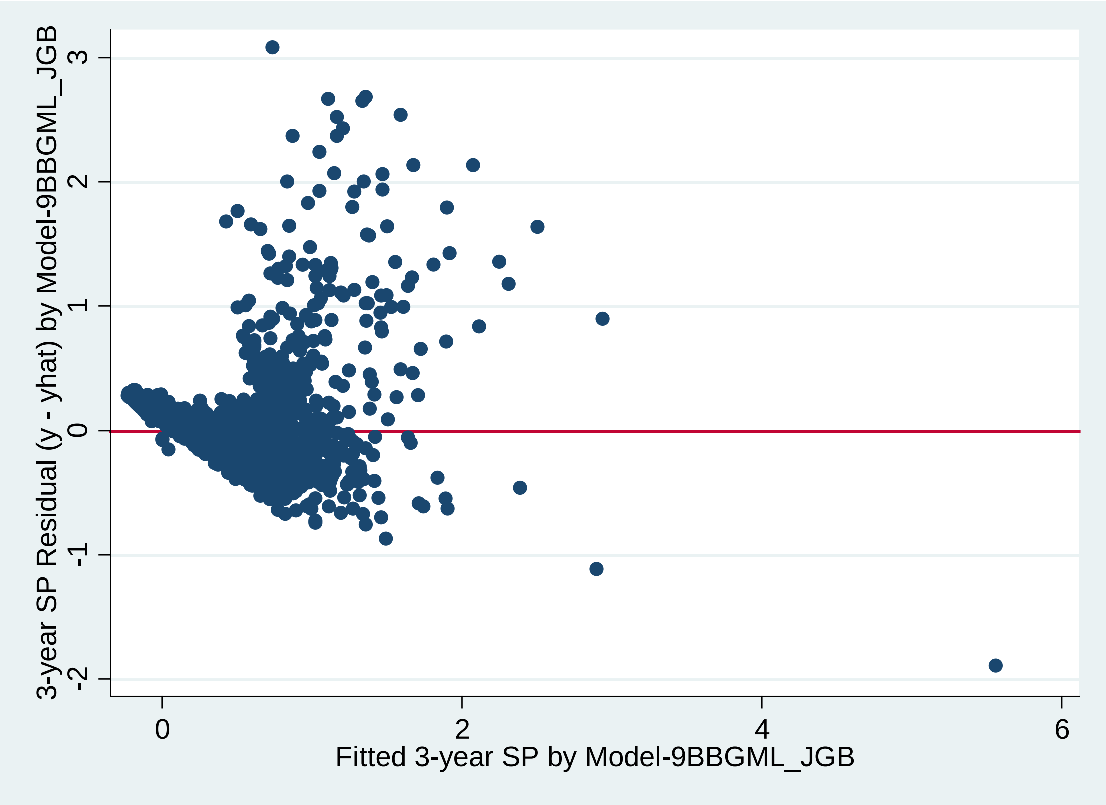

Figure-2: Residual Plot of Static Panel Estimation (Random-Effect)

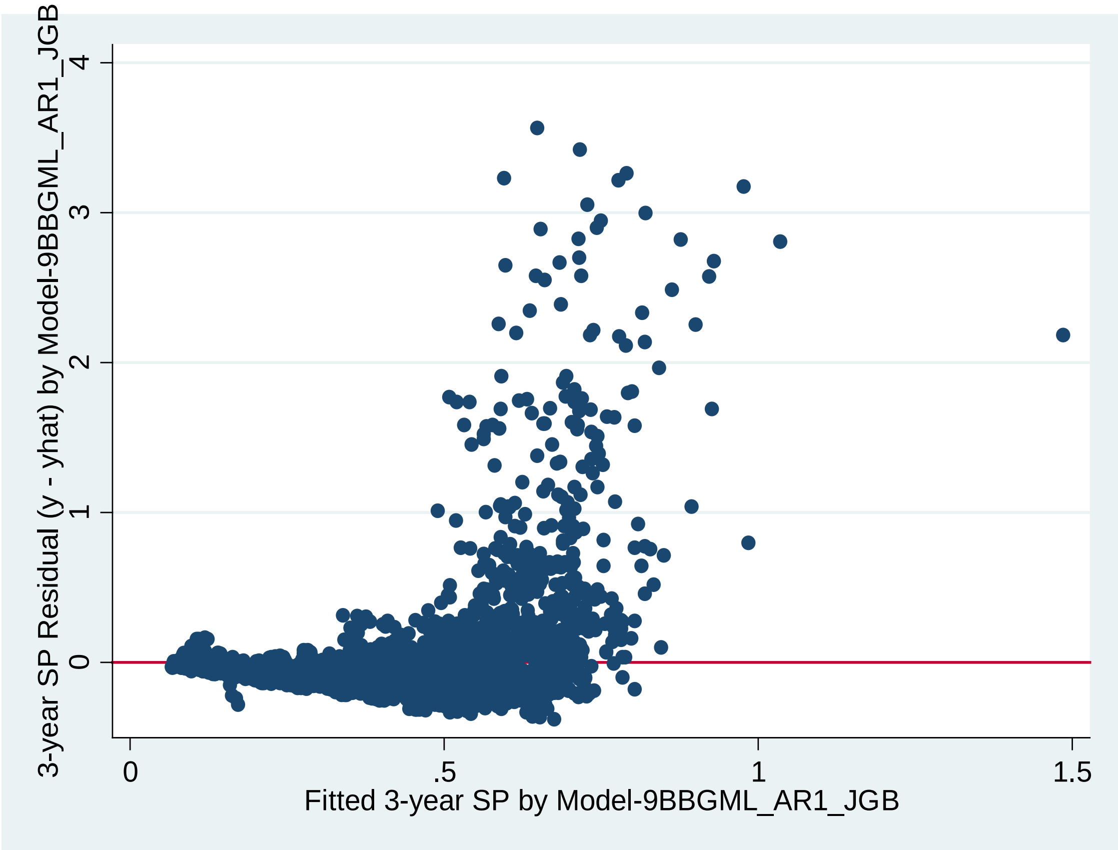

Figure-3: Residual Plot of Dynamic Panel Estimation (AR(1) on Disturbance)

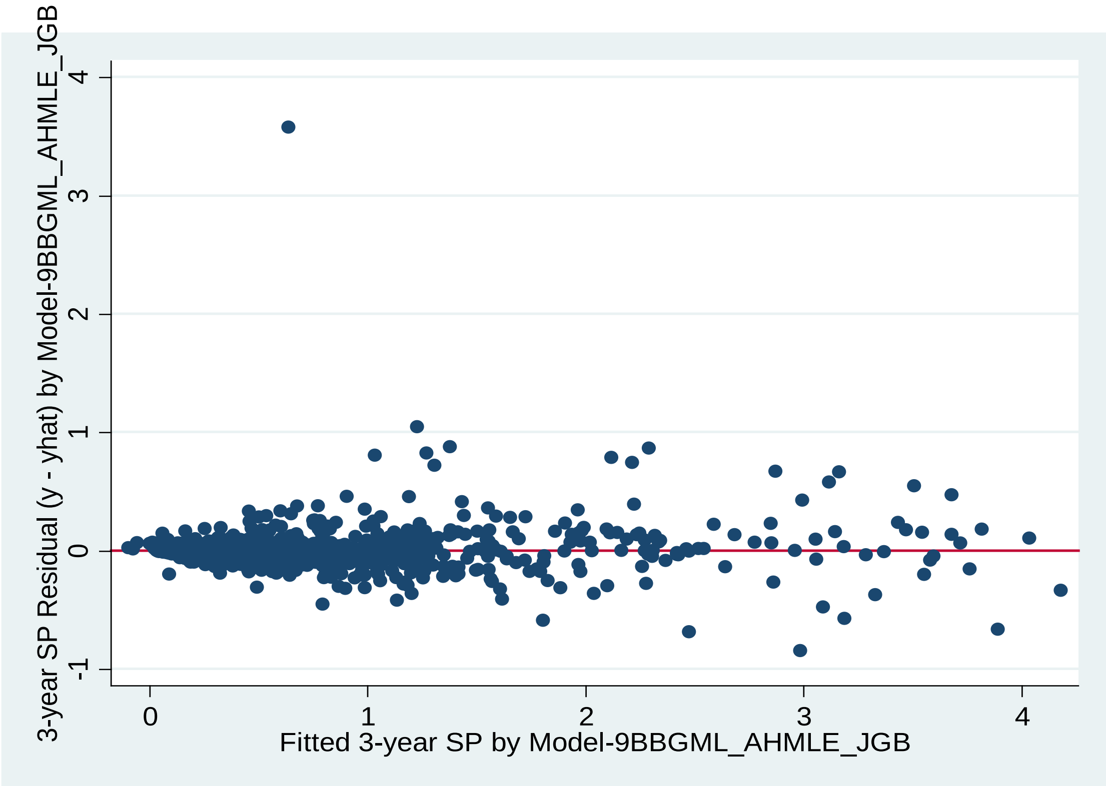

Figure-4: Residual Plot of Dynamic Panel Estimation (Anderson=Hsio)

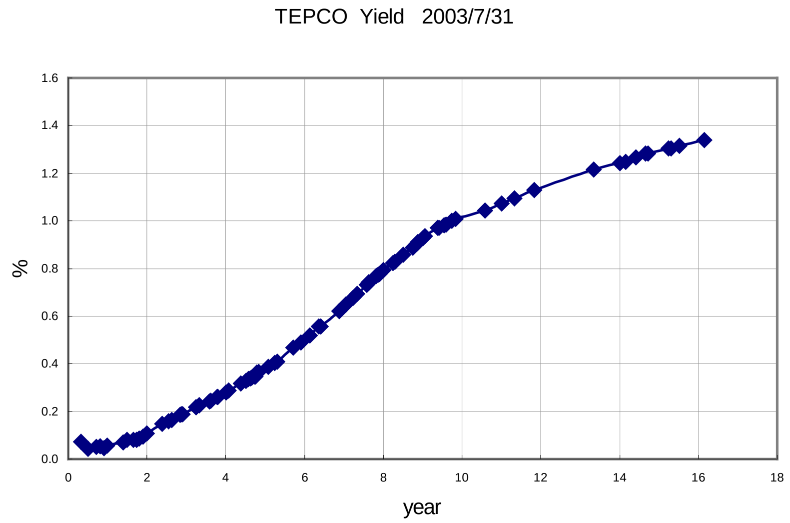

Figure-5(1) Interpolated Yield Curve

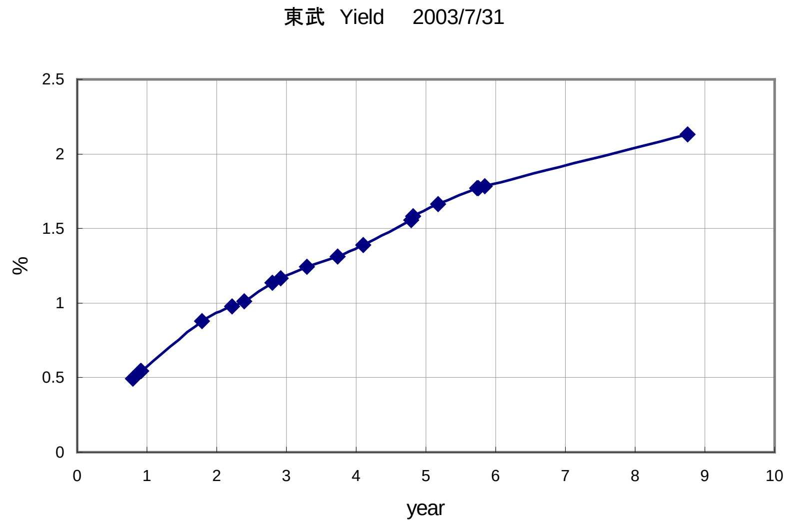

Figure-5(2) Interpolated Yield Curve

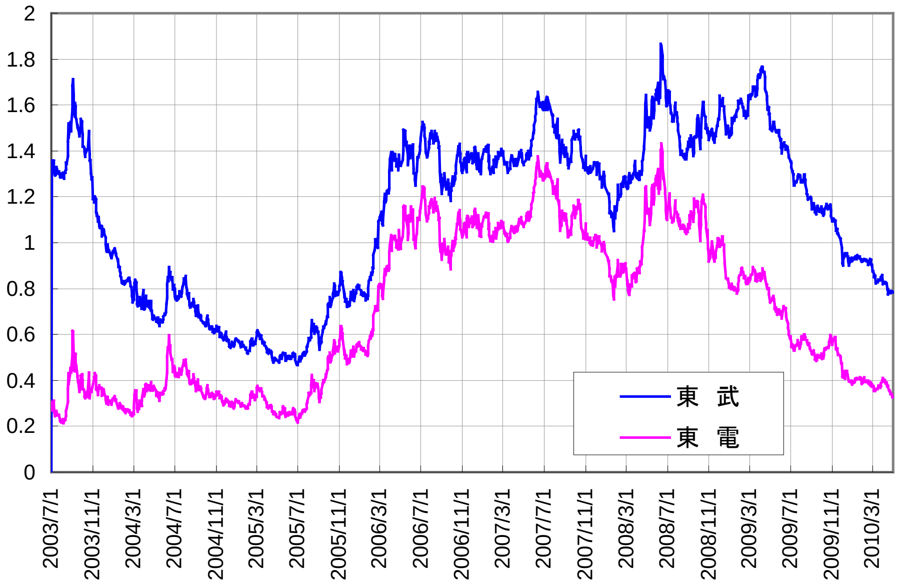

Figure-6: Time-series of Interpolated Spreads

Variable	Defininition	Expected Sign	Obs	Mean	Std.	Min	Max
3-Yr SPREAD	Coorporate bond yield minus JGB yield		4173	0.40	0.45	-0.11	4.21
T_JGBGAP	3-month Tibor minus 3-month JGB yield	+	4264	0.19	0.14	-0.03	0.54
JGBSLOPE (10Y-2Y)	10-year JGB yield minus 2-year JGB yield	−/+	4264	1.06	0.22	0.69	1.64
JGB10Y	10-year JGB yield	−/+	4264	1.49	0.20	0.95	1.93
NKYGROWTH	Growth rata of Nikkei stock index	−/+	4264	0.00	0.06	-0.24	0.13
eHV	20-day historical volatility of individual stock minus estimated historical volatility of each individual	+	4264	0.00	13.69	-76.03	83.84
RATE_RI	R&I credit ratings	+	4264	5.63	2.53	2.00	11.00
GAP3_1DLAG	Highest reported yield minus lowest reported yield in the previous day of 3-Yr SPREAD	+	4172	0.25	0.34	0.01	8.51
GAP3_1DLAG_Adj	GAP3_1DLAG divided by concurrent JGB yield	+	4172	1.60	2.81	0.02	76.61

Table-1(1): Summary Stat Make sample split version

	3-Yr SPREAD	3-Yr SPREAD (Lagged)	T_JGBGAP	JGBSLOPE (10Y-2Y)	JGB10Y	NKY GROWTH	eHV	RATE_RI	GAP3_ 1DLAG	GAP3_ 1DLAG_ Adj
3-Yr SPREAD	1.00									
3-Yr SPREAD(Lagged)	0.97	1.00								
T_JGBGAP	0.42	0.40	1.00							
JGBSLOPE (10Y-2Y)	-0.15	-0.12	-0.44	1.00						
JGB10Y	-0.17	-0.16	-0.42	-0.07	1.00					
NKYGROWTH	0.00	0.02	-0.19	0.28	-0.01	1.00				
eHV	0.32	0.31	0.09	-0.07	-0.03	0.04	1.00			
RATE_RI	0.44	0.45	-0.05	0.03	0.01	0.01	0.33	1.00		
GAP3_1DLAG	0.59	0.57	0.22	0.16	-0.38	0.07	0.21	0.25	1.00	
GAP3_1DLAG_Adj	0.64	0.63	0.16	0.13	-0.30	0.06	0.22	0.39	0.96	1.00

Table-1(2): Correlation Table Make sample split version

	Model 0			Model 1			Model 2			Model 3 RE			Model 3 Pooling			Model 3 FE		
3-Yr SPREAD	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value
T_JGBGAP				1.4094	0.2414 ***	0.0000	1.4493	0.2390 ***	0.0000	0.9686	0.1687 ***	0.0000	0.9239	0.0861 ***	0.0000	0.9837	0.1670 ***	0.0000
JGBSLOPE (10Y-2Y)				0.0530	0.0542	0.3280	0.0415	0.0518	0.4230	-0.0204	0.0446	0.6470	-0.0325	0.0212	0.1260	-0.0223	0.0473	0.6390
JGB10Y	-0.3641	0.0801 ***	0.0000	0.0167	0.0363	0.6460	0.0297	0.0294	0.3120	0.0876	0.0202 ***	0.0000	0.0962	0.0196 ***	0.0000	0.0877	0.0205 ***	0.0000
NKYGROWTH	0.0076	0.0586	0.8960	0.6515	0.1106 ***	0.0000	0.5901	0.1102 ***	0.0000	0.4737	0.0942 ***	0.0000	0.4698	0.0944 ***	0.0000	0.4754	0.0941 ***	0.0000
e_HV							0.0039	0.0010 ***	0.0000	0.0020	0.0007 ***	0.0050	0.0021	0.0005 ***	0.0000	0.0020	0.0007 ***	0.0100
RATE_RI							0.0926	0.0248 ***	0.0000	0.0628	0.0130 ***	0.0000	0.0542	0.0029 ***	0.0000	0.0763	0.0327 **	0.0240
GAP3_1DLAG										1.6064	0.2073 ***	0.0000	1.7743	0.2907 ***	0.0000	1.5833	0.2066 ***	0.0000
GAP3_1DLAG_Adj																		
3-Yr SPREAD (Lagged)																		
_cons	0.9433	0.1483 ***	0.0000	0.0484	0.0623	0.4370	-0.4874	0.1729 ***	0.0050	-0.4009	0.1054 ***	0.0000	-0.3611	0.0449 ***	0.0000	-0.4758	0.1963 **	0.0190
rho_ar																		
# Obs	4173			4173			4173			4172			4172			4172		
# Group	52			52			52			52			52			52		
R-sq:																		
within	0.0392			0.2673			0.3069			0.5269						0.5273		
between	0.0006			0.0320			0.6124			0.7719						0.7518		
overall	0.0256			0.1793			0.4070			0.6120			0.6151			0.6029		

Note: ***:1%, **:5%, *:10%

Table-2(1): Model-1 to -3

	Model 3 Hi-Rate			Model 3 Low-Rate			Model 3 Good-State			Model 3 Bad-State			Model 3 Hi-Rate & Good-State			Model 3 Low-Rate & Bad-State		
3-Yr SPREAD	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value
T_JGBGAP	0.3968	0.0960 ***	0.0000	1.6307	0.3182 ***	0.0000	0.4215	0.0723 ***	0.0000	1.2911	0.2265 ***	0.0000	0.1080	0.0469 **	0.0210	2.0908	0.4433 ***	0.0000
JGBSLOPE (10Y-2Y)	-0.1466	0.0258 ***	0.0000	0.1010	0.0713	0.1560	-0.1096	0.0241 ***	0.0000	0.0498	0.0773	0.5200	-0.1475	0.0177 ***	0.0000	0.3114	0.1287 **	0.0160
JGB10Y	0.1224	0.0139 ***	0.0000	0.0470	0.0275 *	0.0880	0.0615	0.0161 ***	0.0000	-0.0519	0.0480	0.2790	0.0071	0.0130	0.5860	-0.2066	0.0799 ***	0.0100
NKYGROWTH	0.1522	0.0600 **	0.0110	0.8234	0.1625 ***	0.0000	0.2934	0.0842 ***	0.0000	0.6141	0.1254 ***	0.0000	0.4694	0.1114 ***	0.0000	1.0550	0.2173 ***	0.0000
e_HV	0.0020	0.0009 **	0.0220	0.0014	0.0009	0.1280	0.0015	0.0012	0.2010	0.0006	0.0010	0.5310	0.0018	0.0020	0.3690	0.0009	0.0019	0.6340
RATE_RI	0.1049	0.0297 ***	0.0000	0.0830	0.0228 ***	0.0000	0.0392	0.0093 ***	0.0000	0.1175	0.0213 ***	0.0000	0.0516	0.0246 **	0.0360	0.1788	0.0527 ***	0.0010
GAP3_1DLAG	1.3678	0.3602 ***	0.0000	1.4970	0.2287 ***	0.0000	2.0879	0.3816 ***	0.0000	1.1167	0.1786 ***	0.0000	2.4754	0.1378 ***	0.0000	1.0770	0.2160 ***	0.0000
GAP3_1DLAG_Adj																		
3-Yr SPREAD (Lagged)																		
_cons	-0.3211	0.1053 ***	0.0020	-0.7509	0.2394 ***	0.0020	-0.0957	0.0412 **	0.0200	-0.5973	0.1771 ***	0.0010	0.0409	0.0597	0.4930	-1.3460	0.4914 ***	0.0060
rho_ar																		
# Obs	2029			2143			2498			1674			1213			858		
# Group	25			27			52			52			25			27		
R-sq:																		
within	0.6141			0.5761			0.4983			0.4754			0.6302			0.5192		
between	0.7017			0.7305			0.7771			0.6761			0.7787			0.5484		
overall	0.6117			0.5956			0.6301			0.5901			0.7041			0.5213		

Note: ***:1%, **:5%, *:10%

Table-2(2): Model-3 & Sample Split

	Dynamic Model 4 AR1			Dynamic Model 5 AB GMM			Dynamic Model 5 AH MLE		
3-Yr SPREAD	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value
T_JGBGAP	0.4664	0.0409 ***	0.0000	0.0537	0.0253 **	0.0340	0.0588	0.0148 ***	0.0000
JGBSLOPE (10Y-2Y)	-0.1087	0.0273 ***	0.0000	-0.0530	0.0049 ***	0.0000	-0.0618	0.0077 ***	0.0000
JGB10Y	0.0319	0.0218	0.1440	-0.0016	0.0066	0.8120	0.0043	0.0087	0.6240
NKYGROWTH	0.1255	0.0211 ***	0.0000	-0.0126	0.0212	0.5540	-0.0171	0.0258	0.5070
e_HV	0.0002	0.0001	0.2190	0.0004	0.0002 *	0.0590	0.0003	0.0001 ***	0.0070
RATE_RI	0.0617	0.0078 ***	0.0000	-0.0126	0.0119	0.2900	0.0031	0.0009 ***	0.0000
GAP3_1DLAG	0.2900	0.0163 ***	0.0000	0.4310	0.1341 ***	0.0010	0.3989	0.0149 ***	0.0000
GAP3_1DLAG_Adj									
3-Yr SPREAD (Lagged)				0.8625	0.0367 ***	0.0000	0.8782	0.0054 ***	0.0000
_cons	0.0105	0.0540	0.8460	0.1337	0.0636 **	0.0360	0.0424	0.0198 **	0.0320
rho_ar	0.9530								
# Obs	4172			4059			4116		
# Group	52			52			52		
R-sq:									
within	0.4261								
between	0.6335								
overall	0.4435								

Note: ***:1%. **:5%. *:10%

Table-3: Model-4 to -5

	Dynamic Model 5 AH MLE Hi-Rate			Dynamic Model 5 AH MLE Low-Rate			Dynamic Model 5 AH MLE Good-State			Dynamic Model 5 AH MLE Bad-State			Dynamic Model 5 AH MLE Hi-Rate & Good-State			Dynamic Model 5 AH MLE Low-Rate & Bad-State		
3-Yr SPREAD	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value	Coef.	Std.	p-value
T_JGBGAP	-0.0150	0.0199	0.4510	0.1555	0.0217 ***	0.0000	0.0603	0.0209 ***	0.0040	0.0838	0.0247 ***	0.0010	-0.0385	0.0331	0.2450	0.2120	0.0470 ***	0.0000
JGBSLOPE (10Y-2Y)	-0.0800	0.0105 ***	0.0000	-0.0710	0.0106 ***	0.0000	-0.0611	0.0072 ***	0.0000	-0.1286	0.0174 ***	0.0000	-0.0763	0.0118 ***	0.0000	-0.1664	0.0317 ***	0.0000
JGB10Y	0.0129	0.0119	0.2770	0.0117	0.0118	0.3230	-0.0096	0.0078	0.2190	-0.1226	0.0251 ***	0.0000	-0.0425	0.0127 ***	0.0010	-0.1524	0.0446 ***	0.0010
NKYGROWTH	-0.0299	0.0347	0.3890	0.0229	0.0351	0.5140	0.2278	0.0348 ***	0.0000	-0.0345	0.0362	0.3410	0.2998	0.0572 ***	0.0000	0.0592	0.0647	0.3600
e_HV	0.0002	0.0002	0.2840	0.0007	0.0002 ***	0.0000	0.0001	0.0002	0.6100	0.0006	0.0002 ***	0.0020	0.0001	0.0003	0.6900	0.0011	0.0003 ***	0.0000
RATE_RI	0.0050	0.0024 **	0.0340	0.0082	0.0020 ***	0.0000	0.0050	0.0009 ***	0.0000	0.0033	0.0017 **	0.0490	0.0014	0.0023	0.5630	0.0129	0.0048 ***	0.0070
GAP3_1DLAG	0.8356	0.0314 ***	0.0000	0.2851	0.0161 ***	0.0000	1.1948	0.0313 ***	0.0000	0.2848	0.0184 ***	0.0000	1.7406	0.0436 ***	0.0000	0.2881	0.0249 ***	0.0000
GAP3_1DLAG_Adj																		
3-Yr SPREAD (Lagged)	0.7352	0.0137 ***	0.0000	0.8983	0.0060 ***	0.0000	0.7132	0.0094 ***	0.0000	0.9095	0.0085 ***	0.0000	0.6207	0.0150 ***	0.0000	0.8946	0.0117 ***	0.0000
_cons	0.0577	0.0268 **	0.0320	-0.0128	0.0306	0.6740	0.0586	0.0184 ***	0.0010	0.2671	0.0468 ***	0.0000	0.1438	0.0296 ***	0.0000	0.2525	0.0902 ***	0.0050
rho_ar																		
# Obs	2003			2113			2495			1621			1212			830		
# Group	25			27			52			52			25			27		
R-sq:																		
within																		
between																		
overall																		

Note: ***:1%, **:5%, *:10%

Table-4: Model-5 & Sample Split

	Model 3 (Robustness Check)				Dynamic Model 4 AR1 (Robustness Check)				Dynamic Model 5 AB GMM (Robustness Check)				Dynamic Model 5 AH MLE (Robustness Check)			
3-Yr SPREAD	Coef.	Std.		p-value	Coef.	Std.		p-value	Coef.	Std.		p-value	Coef.	Std.		p-value
T_JGBGAP	1.1859	0.1676	***	0.0000	0.4514	0.0415	***	0.0000	0.0943	0.0248	***	0.0000	0.0851	0.0157	***	0.0000
JGBSLOPE (10Y-2Y)	-0.1311	0.0393	***	0.0010	-0.1150	0.0277	***	0.0000	-0.0772	0.0112	***	0.0000	-0.0810	0.0083	***	0.0000
JGB10Y	0.3377	0.0453	***	0.0000	0.0686	0.0223	***	0.0020	0.0404	0.0269		0.1330	0.0370	0.0097	***	0.0000
NKYGROWTH	0.4237	0.0868	***	0.0000	0.1212	0.0214	***	0.0000	-0.0275	0.0228		0.2270	-0.0338	0.0272		0.2140
e_HV	0.0025	0.0007	***	0.0010	0.0002	0.0001		0.1540	0.0006	0.0003	**	0.0220	0.0005	0.0001	***	0.0000
RATE_RI	0.0672	0.0166	***	0.0000	0.0593	0.0080	***	0.0000	-0.0102	0.0113		0.3640	0.0026	0.0008	***	0.0020
GAP3_1DLAG																
GAP3_1DLAG_Adj	0.5669	0.0648	***	0.0000	0.0928	0.0066	***	0.0000	0.1137	0.0514	**	0.0270	0.0970	0.0061	***	0.0000
3-Yr SPREAD (Lagged)									0.8856	0.0368	***	0.0000	0.9075	0.0058	***	0.0000
_cons	-0.7120	0.1523	***	0.0000	-0.0214	0.0554		0.6990	0.0794	0.0403	**	0.0490	0.0140	0.0210		0.5050
rho_ar					0.9538											
# Obs	4172				4172				4059				4116			
# Group	52				52				52				52			
R-sq:																
within	0.4914				0.4019											
between	0.7314				0.6204											
overall	0.5740				0.4177											

Note: ***:1%, **:5%, *:10%

Table-5: Robustness Check (Adjusted Gap: Relative Distance Measure)

<Reference>

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