Credit Spreads on Corporate Bonds and the Macroeconomy in Japan

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Abstract: Using secondary market data on corporate bonds issued in Japan between 1997 and 2005, this paper explores the determinants of the credit spread of corporate bond rates over interest swap rates. We find that credit spreads properly reflect financial factors at the firm level, including debt-to-equity ratios, volatility, and maturity, particularly for longer-term bonds. In addition, an economy-wide factor common among bond issues unable to be captured by firm-level factors, plays an important role in determining credit spreads, and these economy-wide effects to a great extent cancel out firm-level factors for some subsample periods. We also identify possible factors responsible for the significant economy-wide effects.

Keywords: credit spreads, corporate bonds, market liquidity.
JEL classification: G12, G13.

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1. Introduction

Using secondary market data on corporate bonds issued in Japan between 1997 and 2005, this paper empirically investigates the possible determinants of credit spreads on corporate bonds, including financial factors summarized at the level of individual firms as well as macroeconomic and market-wide effects.

According to standard frameworks for bond pricing models, including Merton (1974), credit risks mainly reflect firm-level financial factors responsible for the possibility of individual default, while interest rate risks are only determined by market-wide factors common among individual firms. Typically, these include macroeconomic conditions and monetary policies. One of the more important implications of this model is that firm-specific and macroeconomic factors responsible for the determination of credit spreads may be summarized by variables at the individual firm level. The risk-free rate is the only macroeconomic variable that appears in the standard model. Given this conventional prediction, as long as the set of firm-level explanatory variables is properly chosen to reflect both the firm-specific and macroeconomic components, the credit spreads of corporate bond rates over market interest rates can be explained mostly by firm-level financial conditions. These include debt-to-equity ratios and the volatility of corporate value, along with individual contract clauses, such as maturity and any attached options. In other words, there is little room for credit spreads to be influenced by market-wide effects (except for the risk-free rate) beyond what is captured by these firm-level financial variables and contract clauses.

We carefully and rigorously assess the empirical relevance of the above prediction by raising the following questions: namely, (i) whether credit spreads on corporate bonds reflect firm-level financial factors in a proper way; (ii) whether there are market-wide effects other than firm-level factors; and (iii) if the answer to the second question is in the affirmative, what macroeconomic conditions are responsible for market-wide factors.

Our empirical investigation is motivated mainly by the following observation concerning Japanese corporate bond markets. One of the clear and simple predictions available from standard pricing models of credit risk is the negative correlation between credit spreads and equity prices, which serves as a proxy for corporate valuation. That is, a decrease in equity prices will enhance default risk and thereby raise credit spreads on corporate bonds. Figure 1 plots the relation between the average credit spreads on Moody's A-rated corporate bonds and the average total equity valuation of the issuing firms. As shown, there is indeed a negative correlation between credit spreads and equity valuations for both the period between 1997 and 2002, and the period between 2003 and 2005. Between 2002 and 2003, however, credit spreads declined substantially although equity valuations also fell heavily. The positive correlation in these subsample periods is uniformly observed for highly rated corporate bonds with different maturities (from less than three years to longer than 10 years). Among low-grade corporate bonds, such as Baa rated issues, a positive correlation between credit spreads and equity valuation is again observed for the period between 2001 and 2003 (see Figure 2). In addition, a positive correlation between the two is observed between 1997 and 1999. Credit spreads increased while equity valuation was relatively strong. Such overall consistency and particular inconsistency in the relationship between credit spreads and corporate valuation may help to separate independent market-wide effects on credit spreads from firm-specific factors.

The motivation of this paper is shared with existing empirical literature on U.S. corporate bond pricing. Among empirical papers based on corporate bonds issued in the U.S., Collin-Dufresne, Goldstein and Martin (2001), and Delianedis and Geske (2001) divided the determinants of credit spreads into market-wide factors and firm-level factors. Collin-Dufresne et al. (2001) found that firm-level financial factors, including leverage ratios and equity valuation, play little part in determining credit spreads and that credit spreads are largely subject to market-wide factors possibly associated with overall market liquidity. Delianedis and Geske (2001) established that firm-level financial factors, including the volatility of corporate value, did not contribute to the determination of credit spreads on corporate bonds and that individual credit spreads were heavily influenced by market risks measured in terms of the returns and volatilities of equity market indexes. In addition, Jones, Mason and Rosenfeld (1984) and Huang and Huang (2003) demonstrated that firm-level financial factors do not contribute to corporate bond pricing.[1] Together, these papers suggest that the determination of credit spreads is seriously inconsistent with standard bond pricing theory; in fact, these empirical results act partly as a trigger for the theoretical development of more general models.

In terms of empirical studies concerning corporate bonds issued in Japan, Ueki (1999), Ieda and Ohba (1998) and Ieda (2001) examined the possible determinants of credit spreads, claiming that firm-specific factors are mainly responsible for the determination of credit spreads.[2] However, the fundamental difference from the work based on U.S. corporate bonds and our analysis is that they investigated the relationship between credit spreads and credit ratings, and were unconcerned with the possible effects of the firm-level financial factors underlying these ratings.

Our major findings are summarized as follows. First, credit spreads properly reflect firm-level financial factors, including equity valuation and the volatility of corporate value, particularly for corporate bonds with maturities in excess of 10 years. Second, economy-wide effects also play an important role in determining credit spreads. For the period between 1997 and 1999, and again between 2001 and 2003, an economy-wide effect dominated and cancelled out the effects dictated by the firm-level financial conditions, thereby yielding a positive correlation between credit spreads and equity valuation at the aggregate level. Third, further empirical investigation into market-wide effects demonstrates that the overall deterioration of corporate bond market liquidity during a financial crisis contributed to a significantly positive market-wide effect on credit spreads from 1997 through 1999. Moreover, massive capital inflows into corporate bond markets because of aggressive monetary policy generated a significant aggregate impact between 2001 and 2003.

The remainder of the paper is organized as follows. Section 2 reviews the empirical predictions based on the standard credit risk model. Sections 3 and 4 present empirical

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[1] As a possible exception to the findings of these papers, Longstaff, Mithal and Neil (2005) used the premiums on credit default swaps (CDS) to identify the possible determinants of credit spreads on corporate bonds. They found that credit spreads are largely determined by those firm-specific factors associated with credit risk and liquidity premiums.

[2] Takaoka and McKenzie (2006) amongst others empirically investigate the mechanism determining credit spreads in new issues markets, but not secondary markets, in Japan.

specifications and estimation results for firm-level (or issue-specific) effects and market-wide effects, respectively. Section 5 offers some conclusions.

2. Determinants of credit spreads on corporate bonds

This section briefly reviews a standard model of credit spreads on corporate bonds, thereby lending theoretical support to our empirical specification. More specifically, we base our theoretical foundations on work undertaken by Merton (1974). One basic idea in Merton (1974) is that a default option assigned to stockholders is also a put option issued by bondholders to stockholders. While the assumptions presented by Merton (1974) are simple, they provide a convenient basis for identifying the effects of firm-level factors and market-wide effects on the credit spread. In this regard, Merton (1974) can act as a diagnostic model; that is, if some implications from Merton (1974) are rejected, then the standard framework may need to be modified, and other factors may have to be seriously considered. As discussed briefly in the introduction and in more detail later, frequent rejection of the standard predictions from Merton (1974) using a database of U.S. corporate bond markets acts as a trigger for further theoretical extension and sheds light on the importance of other potential factors, such as market liquidity.

To implement Merton's (1974) model, we make the following simplifying assumptions. First, the term structure of credit risk-free interest rates (market interest rates) is exogenously fixed. Second, in addition to equities, firms issue only straight corporate bonds. Third, the corporate bonds considered are pure discount securities. In other words, bond coupons are ignored. Fourth, a corporate bond does not carry any options, such as conversion or warrants. Fifth, the volatility of returns on corporate value is assumed to be constant over time. Finally, a firm triggers a default option when bond repayment obligations at maturity (corporate liabilities) exceed corporate valuation. In other words, an exercise price in terms of corporate valuation is exactly equal to the bonds outstanding.

As mentioned earlier, following the frequent rejection of a standard version of Merton (1974) using U.S. corporate bond market data, the existing literature has relaxed several of these simplifying assumptions in an important way. For example, in Longstaff and Schwartz (1995), a stochastic process of instantaneous risk-free rates determines the term structure of risk-free interest rates endogenously. Alternatively, Hull et al. (2005) and Gatfaoui (2006) assumed the time-varying volatilities of returns on corporate bonds, and Black and Cox (1976) consider the case where a default option is triggered before maturity. Finally, Leland (1994), Leland and Toft (1996), and Mella-Barral and Perraudin (1997) analyze situations where a trigger point (the exercise price) is determined endogenously because of the strategic interaction between firms and bondholders.

Suppose that a firm issues a straight discount bond at time t whose outstanding amount K_T matures at time T. The corresponding risk-free interest rate for the T_t $\left(T_t = T - t\right)$ term is equal to r_t. If this bond is completely free of default risk, then its price is equal to the discounted value of K_T ($K_T \exp(-r_t \cdot T_t)$). Therefore, an essential consideration in corporate bond pricing is how much a straight corporate bond is further discounted in the presence of credit risk.

As discussed, Merton (1974) interpreted the issuance of a discount bond with a default option as the case where bondholders sell stockholders a European put option on corporate valuation (V_t) at time T, whose exercise price is equal to K_T (repayment obligations). Consequently, corporate bond pricing B_t is discounted from $K_T \exp(-r_t \cdot T_t)$ by the corresponding value of this put option.

Merton (1974) applied the Black–Scholes–Merton formula (Black and Scholes, 1973; Merton, 1973) to the pricing of the put option issued to stockholders by bondholders and derived the corporate bond pricing (B_t) as follows:

$$B_t = V_t \cdot N(-z_t) + K_T \cdot \exp(-r_t \cdot T_t) \cdot N(z_t - \sigma_t \sqrt{T_t}),$$

where $z_t = \dfrac{\log\left(\dfrac{V_t}{K_T}\right) + \left(r_t + \dfrac{\sigma_t^2}{2}\right) \cdot T_t}{\sigma_t \sqrt{T_t}}$. In this derivation, σ_t denotes the volatility of returns on corporate valuation V_t. $N(x)$ is the standard normal cumulative distribution function at x, and log implies a natural logarithmic operator.

The annual yield on the corporate bond y_t is defined as:

$$y_t = -\frac{1}{T_t} \cdot \log \frac{B_t}{K_T},$$

and the credit spread ($spread_t = y_t - r_t$) is derived as:

$$spread_t = -\frac{1}{T_t} \cdot \log\left(\frac{V_t}{K_T \cdot \exp(-r_t \cdot T_t)} \cdot N(-z_t) + N(z_t - \sigma_t \sqrt{T_t}) \right). \tag{1}$$

Equation (1) demonstrates that credit spreads are determined by a single market factor represented by the risk-free interest rate r_t, and three firm-level or issue-specific factors: (i) the corporate leverage ratio defined by $K_T \cdot \exp(-r_t \cdot T_t)/V_t$ (we refer to this as the present value of the leverage ratio in the sense that bond repayments are evaluated in terms of present value); (ii) the volatility of the returns on the corporate valuation σ_t; and (iii) the remaining terms to maturity T_t.

In terms of firm-level factors, credit spreads increase with leverage ratios. This immediately implies that credit spreads are decreasing in corporate valuation or equity valuation. With higher leverage ratios, the probabilities of default are higher, and the corresponding credit risks become larger. An increase in corporate volatility σ_t raises the value of the put option (default option) issued to stockholders by bondholders, thereby lowering corporate bond pricing and enhancing credit spreads. On the other hand, the effect of maturity T_t on credit spreads may not be monotonic. As pointed out by Merton (1974) and Leland and Toft (1996), credit spreads depend on the interaction between maturity T_t and firm-level factors, such as leverage ratios and corporate volatility, in a complicated way.

In addition to these firm-level and issue-specific effects, the pattern of coupons on corporate bonds has potential effects on credit spreads.[3] Like other individual factors, for

[3] Geske (1977) considered explicitly the effect of coupons on corporate bonds, and considered not only redemption at maturity, but also coupon payments up to maturity, as being subject to credit risk.

example, market liquidity may be associated with a particular issue of corporate bonds. As discussed in our empirical specification, firm-level and issue-specific factors other than leverage ratios (or equity valuation), corporate volatility, and maturity are treated as individual effects, such as fixed effects or random effects, in the context of panel data analysis.

One of the most important aspects concerning equation (1) is that the firm-specific and macroeconomic factors responsible for the determination of credit spreads can be basically captured by firm-level and issue-specific variables, such as leverage ratios, corporate volatilities, and maturity. While risk-free interest rates of corresponding maturities may serve as a macroeconomic factor, the effect of changes in risk-free interest rates r_t is only indirect to the extent that the present value version of a leverage ratio $K_T \cdot \exp(-r_t \cdot T_t)/V_t$ declines with r_t. It is easy to prove that there is no effect of changes in r_t on credit spreads through z_t ($z_t = \dfrac{\log\left(\dfrac{V_t}{K_T}\right) + \left(r_t + \dfrac{\sigma_t^2}{2}\right) \cdot T_t}{\sigma_t \sqrt{T_t}}$).

Given the marginal negative effect of r_t, so long as the estimated common factors synchronize negatively with the corresponding market interest rates over time, the presence of common factors may be consistent with the underlying structural model. On the other hand, if the time-series pattern of common factors is quite different from that of market interest rates, then there may be other types of time-varying economy-wide effects unable to be captured by the structural model. Candidates for such common effects include improvement or deterioration in the overall market liquidity of corporate bonds, and dynamic changes in capital flows into corporate bond markets induced by macroeconomic policies, particularly monetary policy.

3. Empirical specification and estimation results for firm-level effects

This section explores the firm-level and issue-specific effects on credit spreads, while the following section investigates the market-wide effects on credit spreads. The first and

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However, Geske's (1977) specification is highly nonlinear, and does not fit simple empirical specification.

second subsections examine empirically the reduced-form implications available from equation (1).

3.1 The relationships between credit spreads and firm-level factors

3.1.1 Econometric specification

This subsection adopts an econometric specification for the level of credit spreads based on equation (1). As expressed in specification (2), we consider the following as firm-level or issue-specific determinants of the credit spreads on corporate bonds: market-evaluated debt-to-equity ratios (with logarithmic transformation $deratio_t^i$), the volatility of returns on corporate valuation (σ_t^i), and the remaining years to maturity (its logarithmic transformation T_t^i), as well as the risk-free rates of corresponding maturities (r_t) and quarterly time dummy variables ($time_t$) as market-wide effects.

$$spread_t^i = intercept + \alpha(deratio_t^i) + \beta \log(\sigma_t^i) + \gamma(T_t^i) + \theta(r_t) + \sum_{t=1997Q.2}^{2004Q.4} \lambda_t(time_t) + \varepsilon_t^i \qquad (2)$$

As equation (1) implies, credit spreads increase with debt-to-equity ratios (positive α) and corporate volatility (positive β). As discussed, however, the sign of the coefficients on maturity may be ambiguous within a standard framework. As in specification (2), we add risk-free rates and quarterly time dummies to capture the market-wide effects on credit spreads. In Section 4, we discuss in detail the pattern of estimated coefficients on these time dummies, and identify potential factors responsible for the market-wide effects.

3.1.2 Data construction

The dependent and explanatory variables are defined as follows. The credit spread ($spread_t^i$) is the spread of a yield on corporate bond *i* over an interest rate swap rate of the same maturity.[4] A major reason for using swap rates instead of yields on government

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[4] The corresponding interest rate swap rate is computed from the term structure of the daily average of mid-points of offer and bid rates quoted by Yagi Euro (a major market-maker) using a linear interpolation method.

bonds as reference safe rates is that yields on Japanese government bonds (JGB) earn a form of convenience, and it is difficult to control for effects of convenience on interest rates.[5] Nevertheless, the choice between swap rates and JGB rates does not affect the overall estimation results.

For yields on corporate bonds, we use the dataset released by Nomura Research Institute (NRI). NRI constructs the dataset by compiling the daily average of mid-points of bid and ask prices that are reported by The Japan Securities Dealers Association. NRI compiles these prices for the above dataset.

The variables representing the debt-to-equity ratios and corporate volatility are constructed as follows. The logarithmic transformation of the debt-to-equity ratio of a firm that issues corporate bond i is defined as $\log\left(debt_t^i / equity_t^i \right)$, where $debt_t^i$ is the total book value of long-term debts (comprising long-term loans, straight bonds, convertible bonds, and warrant bonds), and $equity_t^i$ is the market valuation of equities defined as the product of the stock price per issue and the number of stock issues. To compute the daily outstanding long-term debt, we linearly interpolate loans and debts outstanding from the semiannual or quarterly balance sheets. For this purpose, we use financial statements compiled by NRI. To compute the equity valuation, we use the dataset compiled by NRI for both stock prices and the number of stock issues.[6]

We estimate the conditional volatility of returns on corporate value V_t^i ($= equity_t^i + debt_t^i$) with the following steps. First, we estimate a GARCH(1,1) specification for daily returns on equity valuation $ret_t = \log(equity_t) - \log(equity_{t-1})$ and obtain daily conditional volatility as:

$$V(ret_t \mid ret_{t-1}) = eq\text{-}\sigma_t^2 = intercept + \alpha(ret_{t-1}^2) + \beta(eq\text{-}\sigma_{t-1}^2).$$

[5] More concretely, as Fukuta, Saito, and Takagi (2002) show, JGB yields were severely subject to differences in issue-specific convenience, mainly driven by the degree of the cheapest to deliver (CTD) in the JGB futures market in both the late 1990s and the first half of the 2000s, including our sample period. During that period, the first and second CTD issues were priced extremely highly relative to those with a similar fundamental, and it is quite difficult to derive a unique term structure for JGB markets.

[6] More precisely, the number of stock issues used in this analysis is adjusted according to the TOPIX-type computation.

The estimated daily volatility is then expressed at annual rates by $eq\text{-}\sigma_t^2 \times 240$, where one year amounts to 240 business days. Finally, we translate the estimated volatility on equity valuation into the conditional volatility on corporate valuation using:[7]

$$\sigma_t^2 = \left(eq\text{-}\sigma_t^2 \times 240\right) \times \left(\frac{equity_t}{V_t}\right)^2 .$$

Following the above procedure, we estimate the conditional volatility of the corporate valuation for our sample.[8]

To examine the robustness of the estimation based on the above GARCH characterization, we also use as an alternative specification the following historical volatility using the equity returns of the past twenty business days:

$$eq\text{-}\sigma_t = \sqrt{\frac{1}{20-1} \times \sum_{i=t}^{t-19} \left(ret_i - \frac{\sum_{i=t}^{t-19} ret_i}{20} \right)^2} .$$

In terms of market-wide effects, the interest swap rate with a corresponding maturity to the corporate bond is chosen as the risk-free rate (r_t). With the first quarter of 2005 as a reference point, a quarterly time dummy ($time_t$) is constructed from the second quarter of 1997 through to the fourth quarter of 2004.

The full sample period is between April 1, 1997 and January 31, 2005. During this time, Moody's rated 2,658 public issues of straight corporate bonds in Japan. We

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[7] We implicitly assume that the default probability is rather low given that our sample consists of listed large corporations. As shown by Campbell and Taksler (2003), Schönbucher (2003) and Lando (2004), if the probability of default is relatively high, it is necessary to correct these probabilities using $eq\text{-}\sigma_t = \sigma_t \cdot Call'\left(V_t\right) \cdot \left(\frac{V_t}{equity_t}\right)$ where $Call(V_t)$ denotes the price of a call option. In our computation, we implicitly assume $Call'\left(V_t\right) = 1$.

[8] As Pagan (1984) and Pagan and Ullah (1988) demonstrate, as long as $(\sigma_t^i)^2$ is estimated using a proper specification, the coefficients on the estimated second moments $(\sigma_t^i)^2$ are consistent. It is possible to prove that this consistency also holds for the coefficients on $\log(\sigma_t^i)$.

exclude bonds issued by merged or merging companies, most of which were financial institutions, because it is difficult to compute a precise corporate value for these types of firms. Consequently, our sample consists of 2,305 corporate bonds issued by 174 firms.

We estimate equation (2) and other specifications presented later for the full sample and subsample periods, by rating, and by maturity. Concerning the rating classification, we refer to a rating of Baa or higher as *investment grade*, and a rating of Ba or lower as *speculative grade*.[9] In addition, we estimate equation (2) for Aaa, Aa, A, and Baa bond issues. We also divide the sample of bonds into those with short-term maturities (shorter than three years), middle-term maturities (between three years and seven years), long-term maturities (between seven and 10 years), and ultralong-term maturities (10 years and over).

3.1.3 Estimation results

Tables 1 and 2 provide the estimation results of specification (2) for the GARCH-based volatility and the historical volatility respectively. Considering the simultaneous determination of both the credit spreads and the debt-to-equity ratios, the current debt-to-equity ratio is instrumented by the other explanatory variables as well as by the one-day and two-day lagged debt-to-equity ratios, although no substantial difference is found between the estimation results using OLS and the instrumental variables estimators.[10] Throughout this paper, and following Arellano (1987), we compute robust standard deviations with respect to cross-sectional heteroskedasticity and serial correlation *within the same issue*. Because the random effects model is rejected against the fixed effects model according to the Wu–Hausman test, we report only those estimation results based on the latter.

[9] The yields or credit spreads on speculative grades are missing for the period between August 5, 2002, and September 20, 2002, because low-grade corporate bonds are rather illiquid and their bid/ask prices were not quoted by corporate bond dealers. Hence, the estimation for speculative grade bonds excludes this sample period.

[10] We conduct the Sargan test to check the validity of a set of instrument variables including one-day and two-day lagged debt-to-equity ratios. The null-hypothesis that all instrument variables are exogenous is not rejected at the 5% significance level for the individual rating groups (those consisting of identically rated bonds) except for Baa for a middle term, while the null is sometimes rejected for the semi-aggregated rating groups such as investment/speculative grade bonds.

As shown in Table 1, and consistent with the theoretical predictions, the estimated coefficients of the debt-to-equity ratios are significantly positive in many cases using the full sample period. However, for short-term highly rated bonds (such as Aaa and Aa), the estimated coefficients are significantly negative. This contradicts the theoretical predictions.[11]

As discussed in the introduction, a positive relationship between equity valuation and credit spreads is observed at the aggregate level between 1997 and 1999, and again from 2001 to 2003. To examine the consistency of the firm-level effects for these periods, we estimate equation (2) using the subsample between April 1997 and January 1999, and between October 2001 and December 2002.[12] The coefficients on the debt-to-equity ratios are significantly positive in most cases. These results clearly demonstrate that firm-level financial factors were not responsible for the positive correlation between credit spreads and equity valuation observed at the aggregate level for these particular subsamples.

As shown in Table 1, the full sample period estimation of the coefficients for the GARCH-based volatility is theoretical consistent in most cases, although there are some mixed results. For both investment grade bonds (Baa or higher) and speculative grade bonds (Ba or lower), the estimated coefficients are significantly positive for all terms of maturity. Given more detailed classification among the investment grades, however, the estimated coefficients are negative in Aa for a long-term, A for a short-term, and Baa for middle and ultra-long terms.

According to Table 2, the estimation based on the historical volatility also yields theoretically consistent results in most cases. In addition, the estimated positive coefficients on the volatility are more significant in the historical volatility than in the GARCH-based volatility. However, the estimation using the historical volatility reverses

[11] Such theoretically inconsistent results are observed in not only our estimation on Japanese corporate bonds, but also several papers on US corporate bonds, including Collin-Dufresne et al. (2001), Bedendo et al. (2007), and Bhar and Handzic (2008). Those papers do not offer any convincing explanation for this puzzling result either. While we conjecture that such a result may be driven by missing variables in a linear specification, or non-linearity associated with debt-to-equity ratios, we would like to leave this issue to a future research agenda.

[12] The estimation results for the subsample periods are available upon request.

the theoretically consistent results of the GARCH-based estimation in Aaa for middle and ultra-long terms, and Aa for an ultra-long term.

In terms of maturity effects for investment grade bonds, the coefficients tend to be negative for short and ultralong-term bonds, and positive for middle- and long-term bonds. This indicates that the term structure of credit spreads is nonlinear. With respect to market-wide effects, and as theoretically expected, credit spreads decrease with swap rates in most cases.[13] However, a positive effect of changes in swap rates on credit spreads is observed for middle-, long-, and ultralong-term investment grade bonds for the period between October 2001 and December 2002. Section 4 discusses the time series pattern of the estimated coefficients using quarterly time dummies.

3.2 The relationship between changes in credit spreads and changes in equity valuation

3.2.1 Econometric specification and data construction

Following the empirical investigation on U.S. corporate bonds, including work by Collin-Dufresne et al. (2001), this subsection examines some implications for changes in, not levels of, credit spreads as driven by the firm-level and issue-specific financial conditions in equation (1). That is, a decrease in leverage ratios leads to a decrease in credit spreads. In terms of high-frequency movements, most of the changes in leverage ratios come from changes in the market valuation of equities, with an improvement (deterioration) in equity valuation resulting in a decrease (increase) in the leverage ratios. Therefore, credit spreads should decrease with equity valuation.

We assume that the other factors possibly responsible for changes in credit spreads may be accounted for by changes in the credit rating of a corresponding interval as firm-level effects and by changes in risk-free rates as macroeconomic effects. While we estimate several intervals for changes in credit spreads, from one day through to one quarter, the estimation results do not depend on the choice of time interval. Thus, we

[13] In the extant work on U.S. corporate bond markets, Longstaff and Schwartz (1995) and Duffee (1998) used Treasury rates to proxy as the risk-free rate for corporate bonds issued in the U.S., and found a significant, albeit weak, negative correlation between credit spreads and the risk-free rate.

only report those estimation results based on a one-month interval or 20-business-day changes.

The preceding argument can be captured by the following specification:

$$spread_t^i - spread_{t-20}^i = intercept + \alpha(ret_t^i) + \sum_j \beta_j (Rating\text{-}change_{t,\,j}^i) \\ + \lambda(r_t - r_{t-20}) + \sum_{t=1997Q.2}^{2004Q.4} \gamma_t (time_t) + \varepsilon_t^i \quad , \qquad (3)$$

where $spread_t^i$ is the credit spread of issue i, ret_t^i is the 20-business-day change (between time t and time t – 20) in equity valuation of a company issuing corporate bond i, and $Rating\text{-}change_{t,\,j}^i$ is a dummy variable associated with a j notch change in the credit rating for the corresponding period. In addition to these firm-level variables, we include the 20-business-day change in the risk-free interest rate ($r_t - r_{t-20}$) and a quarterly time dummy ($time_t$) as economy-wide effects,

The 20-business-day change in the market valuation of equities of a company issuing corporate bond i is computed by $ret_t^i = \log(equity_t^i) - \log(equity_{t-20}^i)$. A dummy variable with respect to each change in credit rating of issue i for 20 business days ($Rating\text{-}change_{t,\,j}^i$) is based on a rating by Moody's, whose rating information is compiled by IN Information Data Service. We index the Moody's rating into 20 (the highest rating) through 1 (the lowest rating), compute the numerical change in the indexed rating, and construct a dummy variable for each value of the numerical change in rating. A deterioration in ratings ranges between $j = -11$ and $j = -1$, and an improvement in rating ranges from $j = +1$ to $j = +3$. Because no change in rating ($j = 0$) serves as the reference category, a dummy variable for no change is excluded from the list of explanatory variables.

In terms of market-wide effects, the interest-rate swap rate of the corresponding maturity of a corporate bond is chosen as the risk-free rate (r_t). With the first quarter of 2005 as the reference category, a quarterly time dummy ($time_t$) is constructed from the second quarter of 1997 through to the fourth quarter of 2004.

3.2.2 Estimation results

Tables 3 and 4 report the estimation results of equation (3) for the full sample period. Because, as in Collin-Dufresne et al. (2001), we are mainly interested in the effects of unpredicted movements in equity valuation, we employ an OLS estimator. Following Arellano (1987), we again compute robust standard deviations with respect to cross-sectional heteroskedasticity and serial correlation within the same issue. While most of the issue-specific fixed effects may be removed by the time differences in credit spreads, we still consider issue-specific effects in the estimation. According to the Wu–Hausman test, the random effects model is again rejected against the fixed effects model.

As shown in Table 3, consistent with the reduced-form implications from equation (1), the estimated coefficients on changes in equity valuation are significantly negative in all cases. That is, an increase in leverage ratios through equity devaluation tends to result in larger credit spreads. These results demonstrate that credit spreads reflect firm level factors, more specifically, individual default possibilities, at least in a qualitatively consistent manner.

Table 4 reports the estimated coefficients on the changes in rating. As demonstrated in Table 4, credit spreads decline with rate improvement and increase with rate deterioration during the full sample period.

As discussed before, a positive relationship between equity valuation and credit spreads, sharply inconsistent with any theoretical prediction, is observed at the aggregate level between 1997 and 1999 and between 2001 and 2003. The coefficients on changes in equity valuation are significantly negative in all cases between 1997 and 1999.[14] On the other hand, the coefficients on changes in equity valuation are significantly negative in all cases between 2001 and 2002. These findings clearly demonstrate that firm-level financial factors were not responsible for the positive correlation between credit spreads and equity valuation observed at the aggregate level for these particular subsamples.

[14] The estimation results for the subsample periods are available upon request.

As theoretically expected, an increase in swap rates results in a decrease in credit spreads in most cases. However, a positive effect of changes in swap rates on credit spreads is observed among middle- and long-term corporate bonds for the period between October 2001 and November 2002.[15] Section 4 discusses the time series pattern in effects other than the risk-free rate.

In contrast with the estimation results of Collin-Dufresne et al. (2001), our estimated coefficients on changes in equity valuation are significantly negative. In our sample of corporate bonds issued in Japan, credit spreads tended to reflect firm-level default possibilities in a qualitatively consistent manner.

4. Empirical specifications and estimation results for the market-wide effects

This section investigates how market-wide effects on credit spreads behave, and which factors are responsible for the dynamic changes in market-wide effects.[16] We first explore the properties of the time series pattern of market-wide effects (λ_t) in equation (2). We also discuss some market episodes likely to be associated with the time series pattern in order to understand the possible driving forces responsible for these effects. We then attempt to identify several particular factors that drive the market-wide dynamics in individual credit spreads.

4.1 Time-series patterns in market-wide effects and some market episodes

Figure 3 plots the time series of estimated coefficients on quarterly time dummies with 95% confidence bounds for short-term, middle-term, long-term, and ultralong-term investment grades (Baa or higher), while Figure 4 constructs these for short-term, middle-term, and long-term speculative grades (Ba or lower). In both of these figures, the first quarter of 2005 serves as the reference point for measuring the time effects.

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[15] Longstaff and Schwartz (1995) did not observe the positive effect of risk-free rates on credit spreads and Duffee (1998) in their study of the relationship between credit spreads and risk-free rates for bonds issued in the U.S.

[16] Anderson and Sundaresan (2000) adopted an alternative method to identify market-wide effects on credit spreads. Using the average debt-to-equity ratio for the entire nonfinancial sector and the volatility of stock market indexes, they found that these variables could explain yields on BBB-rated corporate bonds in the U.S.

As Figures 3 through 4 clearly demonstrate, market-wide effects contributed to an expansion of credit spreads between early 1997 and late 1998. As discussed in the introduction, corporate bonds rated as Baa (Figure 2) yielded increases in credit spreads with rises in stock prices for that period. Given the qualitatively reasonable estimation for firm-level effects, it follows that market-wide effects largely cancelled out the decreases in credit spreads induced by firm-level equity valuation.

We have two remarks concerning the above period. First, the 'flight to quality' phenomenon emerged during the financial crisis in 1997 and 1998. That is, funds shifted from relatively risky markets (such as corporate bond markets) to relatively safe markets (such as JGB markets or money markets). In addition to such a decrease in demand for corporate bonds, the increase in new corporate bonds issues as a supply factor contributed to a rise of corporate bond yields, thereby raising credit spreads.

Second, two companies that issued corporate bonds went bankrupt. Yaohan (a nationwide supermarket chain) and Nihon Kokudo Kaihatsu (a large-scale general contractor) became insolvent in 1997. Contrary to earlier custom, their main banks never bought back the outstanding corporate bonds at face value. Consequently, the corporate bonds issued by these companies were in default. As a result, many investors, particularly institutional investors, revised credit spreads upwards. Conversely, market-wide effects have contributed to continuous declines in credit spreads since early 1999. The flight to quality phenomenon, which had been responsible for market-wide increases in credit spreads, disappeared after public injections into private banks in early 1999. Because of a zero-interest policy initiated in February 1999, and a quantity-easing policy implemented in March 2001, rich funds held by public and private financial institutions began to flow into corporate bond markets in search of relatively profitable investment opportunities; outstanding corporate bonds held by public and private financial institutions increased continuously and substantially from 1999.[17]

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[17] Baba, Nakashima, Shigemi and Ueda (2006) investigate the issuance rates of negotiable certificates of deposit (NCD). They demonstrate that improvement in the credit conditions of issuing banks could not fully account for the decline in NCD rates after 1999. They suggest instead that the aggressive monetary policy pursued by the Bank of Japan was partially responsible for negative market-wide effects on NCD rates.

This flow into Japanese corporate bond markets was temporarily terminated by the bankruptcy of MyCal (a large supermarket chain) in September 2001. As a result, all 27 corporate bonds issues issued by MyCal were in default. At the same time, investors again revised credit spreads upwards, particularly for middle-, long-, and ultralong-term investment grades, and speculative grades.[18] However, credit spreads on short-term investment grades were free from such negative effects and continued to decline.

However, the effect of the default of MyCal was only temporary. Public and private financial institutions resumed investment in corporate bonds and even in low-grade corporate bonds. As discussed, credit spreads declined for issues overall, although equity valuation slumped until late 2003. That is, a market-wide effect induced by an aggressive monetary policy continued to cancel out the increase in credit spreads driven by equity devaluation for individual firms during that period.

4.2 Quantitative assessment of driving forces responsible for market-wide effects

In this subsection, we choose five variables to describe changes in market-wide effects, and we add these to equation (2) as additional explanatory variables:

$$\begin{aligned} spread_t^i = & \; intercept + \alpha(deratio_t^i) + \beta \log(\sigma_t^i) + \gamma(T_t^i) + \theta(r_t) \\ & + \lambda(Swap_t) + \mu \log(CBv_t) + \xi \log(JGBv_t) \\ & + \tau \log(HPM_t) + \varphi(DIa_t) + \sum_{t=1997Q.2}^{2004Q.4} \gamma_t(time_t) + \varepsilon_t^i \end{aligned} \quad , \quad (4)$$

where $Swap_t$, CBv_t, $JGBv_t$, HPM_t, and DIa_t denotes 10-year swap spreads, the velocity of corporate bond markets, the velocity of government bond markets, high-powered money, and the diffusion index of financial positions, respectively. These

[18] The bonds issued by Mycal had been downgraded quickly since the summer of 2001; more concretely, from Ba3 to B2 on July 31, 2001, to Caa1 on September 14, 2001, to Caa3 on November 22, 2001, to C in November 26, 2001, and no more rating on December 26, 2003. Such a consecutive downgrading of Mycal bonds triggered a serious concern about low-grade corporate bonds, and contributed to a fund shift from low-grade to high-grade bonds. Such anxiety about low-grade corporate bonds might have helped to yield the observed difference in market-wide effects between speculative and investment grades during the corresponding period.

additional explanatory variables are thought to help capture the overall market liquidity of corporate bonds.[19]

More precisely, the first three variables are associated with the market liquidity of corporate bonds. The 10-year swap spread ($Swap_t$) is the difference in daily 10-year rates between government bonds and interest rate swaps. As discussed in Collin-Dufresne et al. (2001), swap spreads represent the market liquidity of privately issued bonds relative to public bonds; higher swap spreads imply a lower degree of liquidity in corporate bond markets.[20] The velocity of corporate and government bond markets (CBv_t and $JGBv_t$) is defined as the ratio of the monthly trading volume to the outstanding amount in each bond market. Obviously, a higher velocity suggests an improvement in market liquidity.

We choose high-powered money (HPM_t) as a monetary factor. Following Bernanke and Mihov (1998), we de-trend the monthly time series of high-powered money based on deviation from the three-year moving average. Finally, we specify the diffusion index concerning the current financial positions of large corporations (DIa_t) as a measure of financial need for the corporate sector. The Bank of Japan constructs the quarterly series of the diffusion index by counting firms that consider financial conditions as currently improved less those that do not. Hence, lower values of the diffusion index indicate more severe liquidity constraints.

Using linear interpolation, the daily time series of market velocity are constructed from the monthly series of CBv_t, $JGBv_t$, and HPM_t, and from the quarterly series of DIa_t. In addition, we take a logarithm for CBv_t, $JGBv_t$, and HPM_t. Table 5 reports the

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[19] As long as a model of Merton (1974) holds properly, and our linear regression or equation (2) serves as a proper specification, any macroeconomic effect works on credit spreads only through the variables listed in equation (2), in particular debt-to-equity ratios and interest rates. Consequently, any additional macroeconomic variable does not offer explanatory power for credit spreads under the Merton model. Thus, when macroeconomic variables have significant effects on credit spreads, there may be some effect other than the credit risk channel captured by the Merton model. Given this reasoning, we may interpret significant effect of macroeconomic variables on credit spreads as not credit premiums, but either supply/demand conditions or liquidity premiums.

[20] The Japanese tax code allowed financial institutions to avoid the market valuation of interest-rate swap contracts during the sample period. This special tax treatment promoted active speculation in interest-rate swap markets by financial institutions. Consequently, swap spreads in Japan were partially subject to the effect of speculation induced by tax treatment.

estimation results of equation (4) for the full sample period (between April 1997 and January 2005). In what follows, we also report estimation results for the two subsample periods when a positive correlation between credit spreads and equity valuation is observed: the first subperiod between April 1997 and January 1999 and the second subperiod between October 2001 and December 2002.[21]

As in Collin-Dufresne et al. (2001), the coefficient on swap spreads ($Swap_t$) is found to be significantly positive for the full sample estimation. That is, when corporate bond markets are less liquid than government bond markets (swap spreads are larger), credit spreads tend to be larger. This tendency is more noticeable for bonds with longer maturities and for speculative grades. For the first subperiod between April 1997 and January 1999, however, the coefficient on $Swap_t$ is estimated to be negative. The temporary and substantial drop in swap spreads during late 1998 and early 1999 may be responsible for the estimated coefficient being negative (see Figure 5).

The coefficient on the velocity of corporate bond markets (CBv_t) is estimated to be significantly negative for the full sample estimation; credit spreads tend to decrease with an increase in corporate bond market liquidity. The estimated coefficient is larger in magnitude for the second subperiod between October 2001 and December 2002 and for speculative grade bonds. This indicates that a remarkable improvement in the overall market liquidity of corporate bonds was responsible for a dramatic decline in the credit spreads of speculative grades (see Figure 6).

On the other hand, the coefficient on the velocity of government bond markets ($JGBv_t$) differs in sign between the first and second half of the full sample period. For the first subperiod between 1997 and 1999, the coefficient is significantly positive, while it is significantly negative for the second subperiod between 2001 and 2003. The estimation result of the first subperiod provides some evidence of the flight to quality (from corporate bond markets to government bond markets). Figure 6 shows that during late 1998 and early 1999, the velocity of corporate bond markets declined, while that of government bond markets increased.

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[21] The estimation results for the subsample periods are available upon request.

The coefficient on high-powered money (HPM_t) is significantly negative in most cases. In particular, the estimated coefficient is larger in absolute terms for short-term bonds: with aggressive money supply, short-term private bonds may have been a close substitute for credit risk-free bonds (public bonds). The coefficient on the diffusion index of current financial positions (DIa_t) is estimated to be significantly negative. That is, when liquidity constraints are less binding, credit spreads tend to decrease. This tendency is more noticeable in the second subperiod between 2001 and 2003 and among the speculative grades. That is, together with the overall market liquidity of corporate bond markets, improved financial conditions may be responsible for the dramatic and substantial decline in the credit spreads of speculative grades.

As the above results demonstrate, the observed market-wide effects common in individual credit spreads reflect not only the market liquidity of corporate bonds but also the overall financial condition of the corporate sector. In addition, credit spreads are found to be subject to aggressive monetary policy.

5. Conclusions

Using data on corporate bonds issued in Japan between 1997 and 2005, this paper considers the possible determinants of the credit spreads of corporate bond rates over interest swap rates. We find that credit spreads reasonably reflect firm-level financial factors, including debt-to-equity ratios, volatility, and maturity.

Overall, the results indicate that firm and issue-specific factors influence credit spreads in a quite reasonable manner. These findings contrast sharply with similar work on U.S. corporate bonds where firm level financial conditions were found not to play any significant role in determining individual credit spreads. In this regard, corporate bond pricing in the Japanese market is more consistent with a standard version of Merton (1974) than the U.S. market.

On the other hand, an economy-wide factor common among bond issues, as measured by time effects, plays an important role in determining credit spreads. This aspect is seriously inconsistent with Merton's (1974) standard model where macroeconomic effects are mostly captured by firm-level variables along with risk-free rates. That is, the

Japanese market shares with the U.S. market the feature that market-wide effects, including market liquidity, are significant determinants of credit spreads.

This common factor had particularly significant effects on the credit spreads observed between 1997 and 1998, when financial markets were subject to liquidity crises, and between 2001 and 2003, when the Bank of Japan implemented a quantity-easing policy with zero overnight money market rates. During both periods, the economy-wide effect largely cancelled out the firm-level factors. In the earlier period, credit spreads increased even though individual stock prices (or equivalently corporate values) were still firm, while in the more recent period, credit spreads declined substantially, although equity valuation also fell heavily. Empirical analysis of the more recent period indicates that credit risks valuated downwards because of the rich liquidity in corporate bond markets.

One limitation of our empirical analysis is that we ignore issue-specific or firm-specific liquidity factors by assuming that liquidity effects are market-wide. Among recent work in this area, Chen, Lesmond, and Wei (2007) demonstrate empirically that U.S. credit spreads are subject not only to market-wide liquidity factors but also to issue-specific liquidity, as measured by the issue-by-issue bid–ask spreads and the frequency of individual transactions. Ericsson and Renault (2006) present theoretically the interaction between credit risks and issue-specific liquidity. We would like to extend our research along this line of inquiry.

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Table 1: Regression of Credit Spreads on Debt-equity Ratios, GARCH-based Volatilities, Maturities, and Swap Rates

Full Period (April 1, 1997–January 31, 2005)

Maturities	Independent Variables	Rating Groups						
		Investment-grade	Speculative-grade	Investment-grade				
				A or Higher	Aaa	Aa	A	Baa
Short	$deratio_t^i$	0.067	1.179	-0.006	-0.580	-0.036	0.006	0.049
		(0.002)	(0.021)	(0.002)	(0.092)	(0.007)	(0.002)	(0.003)
	$\log \sigma_t^i$	0.032	0.352	0.016	0.395	0.032	-0.011	0.005
		(0.011)	(0.055)	(0.016)	(0.530)	(0.017)	(0.007)	(0.013)
	T_t^i	-0.085	0.101	-0.039	0.079	-0.051	-0.064	-0.133
		(0.003)	(0.014)	(0.003)	(0.011)	(0.004)	(0.004)	(0.006)
	r_t	-0.144	-0.116	-0.188	-0.235	-0.186	-0.116	-0.104
		(0.014)	(0.038)	(0.022)	(0.085)	(0.027)	(0.012)	(0.015)
R-squares (R^2)		0.052	0.271	0.029	0.033	0.028	0.204	0.155
the number of issues		1352	396	750	110	422	344	718
Middle	$deratio_t^i$	0.109	1.149	0.091	0.079	0.007	0.060	0.107
		(0.001)	(0.016)	(0.001)	(0.006)	(0.001)	(0.001)	(0.002)
	$\log \sigma_t^i$	0.105	0.115	0.007	0.035	0.001	0.010	-0.005
		(0.008)	(0.028)	(0.005)	(0.015)	(0.003)	(0.006)	(0.008)
	T_t^i	0.309	1.829	0.066	0.003	0.038	0.206	0.478
		(0.007)	(0.120)	(0.005)	(0.009)	(0.003)	(0.009)	(0.012)
	r_t	-0.046	-0.122	-0.040	-0.003	-0.052	-0.055	-0.053
		(0.002)	(0.019)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
R-squares (R^2)		0.454	0.430	0.651	0.805	0.819	0.744	0.542
the number of issues		1472	351	846	97	403	448	774
Long	$deratio_t^i$	0.109	0.400	0.048	0.067	0.009	0.042	0.045
		(0.002)	(0.011)	(0.001)	(0.007)	(0.001)	(0.002)	(0.003)
	$\log \sigma_t^i$	0.024	0.091	0.001	0.151	-0.005	0.014	0.003
		(0.009)	(0.031)	(0.005)	(0.019)	(0.003)	(0.007)	(0.015)
	T_t^i	0.701	1.762	0.657	0.832	0.540	0.736	0.812
		(0.023)	(0.421)	(0.016)	(0.043)	(0.010)	(0.025)	(0.050)
	r_t	-0.071	-0.053	-0.071	-0.085	-0.088	-0.050	-0.082
		(0.002)	(0.019)	(0.001)	(0.003)	(0.001)	(0.002)	(0.004)
R-squares (R^2)		0.598	0.747	0.683	0.772	0.870	0.821	0.737
the number of issues		679	53	478	55	262	239	238
Ultra-long	$deratio_t^i$	0.192	-	0.098	0.237	0.027	0.112	0.053
		(0.002)	-	(0.002)	(0.022)	(0.001)	(0.005)	(0.009)
	$\log \sigma_t^i$	0.045	-	0.011	0.040	0.029	0.026	-0.016
		(0.011)	-	(0.009)	(0.051)	(0.006)	(0.015)	(0.030)
	T_t^i	-0.257	-	-0.159	0.562	-0.411	0.001	0.097
		(0.015)	-	(0.011)	(0.080)	(0.011)	(0.030)	(0.113)
	r_t	-0.108	-	-0.101	-0.117	-0.097	-0.064	-0.085
		(0.002)	-	(0.001)	(0.003)	(0.001)	(0.003)	(0.009)
R-squares (R^2)		0.558	-	0.673	0.539	0.772	0.802	0.743
the number of issues		473	-	400	74	251	166	86

1. The results are based on instrumental variable estimation of equation (2) with fixed effects during the period between April 1, 1997 and January 31, 2005. Instrumental variables include constants, $deratio_{t-1}^i$, $deratio_{t-2}^i$, $\log \sigma_t^i$, T_t^i, r_t, and quarterly time dummy variables.

2. The number in a parenthesis is a robust standard error of a fixed effect estimate. The reported standard error based on Arellano (1987) is robust with respect to cross-sectional heteroskedasticity and within-issue serial correlation.

3. For estimation of speculative grades, the sample period between August 5, 2002 and September 20, 2002 is excluded, because bid/ask prices of speculative grades were not quoted by corporate bond dealers at all, thereby credit spreads on speculative grades are missing between the two.

Table 2: Regression of Credit Spreads on Debt-equity Ratios, Historical Volatilities, Maturities, and Swap Rates

Full Period (April 1, 1997–January 31, 2005)

Maturities	Independent Variables	Rating Groups						
		Investment-grade	Speculative-grade	Investment-grade				
				A or Higher	Aaa	Aa	A	Baa
Short	$deratio_t^i$	0.079	1.245	-0.004	-0.612	-0.037	0.006	0.071
		(0.002)	(0.024)	(0.002)	(0.088)	(0.007)	(0.002)	(0.003)
	$\log \sigma_t^i$	0.029	0.243	0.018	0.104	0.004	0.028	0.032
		(0.002)	(0.019)	(0.003)	(0.024)	(0.004)	(0.002)	(0.003)
	T_t^i	-0.082	0.110	-0.039	0.074	-0.050	-0.066	-0.134
		(0.003)	(0.014)	(0.003)	(0.012)	(0.004)	(0.004)	(0.006)
	r_t	-0.141	-0.087	-0.185	-0.220	-0.188	-0.098	-0.096
		(0.014)	(0.038)	(0.023)	(0.085)	(0.027)	(0.012)	(0.017)
R-squares (R^2)		0.049	0.272	0.029	0.033	0.028	0.218	0.146
the number of issues		1352	396	750	110	422	344	718
Middle	$deratio_t^i$	0.120	1.230	0.097	0.069	0.006	0.057	0.115
		(0.001)	(0.017)	(0.001)	(0.006)	(0.001)	(0.001)	(0.002)
	$\log \sigma_t^i$	0.012	0.204	0.011	-0.003	0.001	0.011	0.017
		(0.001)	(0.010)	(0.0004)	(0.001)	(0.0003)	(0.001)	(0.001)
	T_t^i	0.304	1.703	0.017	0.023	0.035	0.143	0.462
		(0.007)	(0.123)	(0.004)	(0.010)	(0.003)	(0.007)	(0.013)
	r_t	-0.043	-0.107	-0.037	-0.009	-0.056	-0.049	-0.052
		(0.002)	(0.020)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
R-squares (R^2)		0.462	0.433	0.684	0.808	0.822	0.796	0.545
the number of issues		1472	351	846	97	403	448	774
Long	$deratio_t^i$	0.124	0.384	0.064	0.058	0.010	0.049	0.043
		(0.002)	(0.012)	(0.001)	(0.007)	(0.001)	(0.002)	(0.003)
	$\log \sigma_t^i$	0.013	0.012	0.004	0.012	-0.003	0.005	0.001
		(0.001)	(0.012)	(0.0004)	(0.001)	(0.0003)	(0.001)	(0.002)
	T_t^i	0.673	2.156	0.656	0.833	0.563	0.723	0.830
		(0.024)	(0.428)	(0.016)	(0.045)	(0.010)	(0.027)	(0.050)
	r_t	-0.072	-0.067	-0.072	-0.087	-0.088	-0.051	-0.087
		(0.002)	(0.020)	(0.001)	(0.003)	(0.001)	(0.002)	(0.004)
R-squares (R^2)		0.601	0.747	0.685	0.776	0.873	0.816	0.742
the number of issues		679	53	478	55	262	239	238
Ultra-long	$deratio_t^i$	0.196	-	0.097	0.256	0.025	0.095	0.056
		(0.002)	-	(0.002)	(0.023)	(0.001)	(0.004)	(0.009)
	$\log \sigma_t^i$	0.008	-	0.007	-0.012	-0.0003	0.015	0.007
		(0.001)	-	(0.0004)	(0.003)	(0.0003)	(0.001)	(0.004)
	T_t^i	-0.335	-	-0.188	0.575	-0.427	0.064	0.292
		(0.015)	-	(0.011)	(0.085)	(0.011)	(0.028)	(0.115)
	r_t	-0.108	-	-0.102	-0.126	-0.098	-0.069	-0.093
		(0.002)	-	(0.001)	(0.003)	(0.001)	(0.003)	(0.010)
R-squares (R^2)		0.597	-	0.691	0.542	0.775	0.846	0.757
the number of issues		473	-	400	74	251	166	86

1. The results are based on instrumental variable estimation of equation (2) with fixed effects during the period between April 1, 1997 and January 31, 2005. Instrumental variables include constants, $deratio_{t-1}^i$, $deratio_{t-2}^i$, $\log \sigma_t^i$, T_t^i, r_t, and quarterly time dummy variables.
2. The number in a parenthesis is a robust standard error of a fixed effect estimate. The reported standard error based on Arellano (1987) is robust with respect to cross-sectional heteroskedasticity and within-issue serial correlation.
3. For estimation of speculative grades, the sample period between August 5, 2002 and September 20, 2002 is excluded, because bid/ask prices of speculative grades were not quoted by corporate bond dealers at all, thereby credit spreads on speculative grades are missing between the two.

Table 3: Relationship between Changes in Credit Spreads and Firm Equity Returns

Full Period (April 1, 1997–January 31, 2005)

Maturities	Independent Variables	Rating Groups						
		Investment-grade	Speculative-grade	Investment-grade				
				A or Higher	Aaa	Aa	A	Baa
Short	ret_t^i	-0.018	-0.391	-0.048	-0.292	-0.116	-0.032	-0.017
		(0.008)	(0.033)	(0.017)	(0.220)	(0.031)	(0.007)	(0.008)
	$r_t - r_{t-20}$	-0.067	0.135	-0.114	-0.266	-0.122	-0.015	-0.022
		(0.023)	(0.014)	(0.040)	(0.287)	(0.051)	(0.009)	(0.018)
R-squares (R^2)		0.006	0.050	0.010	0.016	0.010	0.028	0.007
the number of issues		1365	400	764	108	422	361	727
Middle	ret_t^i	-0.041	-0.177	-0.039	-0.033	-0.036	-0.048	-0.042
		(0.002)	(0.012)	(0.002)	(0.006)	(0.002)	(0.003)	(0.002)
	$r_t - r_{t-20}$	-0.026	0.029	-0.033	-0.019	-0.027	-0.043	-0.022
		(0.001)	(0.005)	(0.001)	(0.019)	(0.001)	(0.001)	(0.001)
R-squares (R^2)		0.109	0.112	0.189	0.153	0.210	0.223	0.123
the number of issues		1422	342	823	94	388	446	756
Long	ret_t^i	-0.024	-0.116	-0.020	-0.193	-0.012	-0.023	-0.031
		(0.001)	(0.022)	(0.002)	(0.026)	(0.001)	(0.002)	(0.002)
	$r_t - r_{t-20}$	-0.050	0.002	-0.044	-0.080	-0.033	-0.049	-0.063
		(0.001)	(0.010)	(0.025)	(0.026)	(0.001)	(0.002)	(0.002)
R-squares (R^2)		0.197	0.188	0.181	0.073	0.214	0.274	0.281
the number of issues		564	45	430	51	252	206	174
Ultra-long	ret_t^i	-0.074	-	-0.070	-0.441	-0.065	-0.067	-0.110
		(0.003)	-	(0.003)	(0.017)	(0.002)	(0.058)	(0.010)
	$r_t - r_{t-20}$	-0.074	-	-0.072	-0.121	-0.073	-0.063	-0.103
		(0.001)	-	(0.001)	(0.003)	(0.001)	(0.002)	(0.004)
R-squares (R^2)		0.177	-	0.186	0.224	0.194	0.248	0.272
the number of issues		239	-	218	46	155	104	35

1. The results are based on fixed effect estimation of equation (3) during the period between April 1, 1997 and January 31, 2005.
2. The number in a parenthesis is a robust standard error of a fixed effect estimate. The reported standard error based on Arellano (1987) is robust with respect to cross-sectional heteroskedasticity and within-issue serial correlation.
3. For estimation of speculative grades, the sample period between August 5, 2002 and September 20, 2002 is excluded because bid/ask prices of speculative grades were not quoted by corporate bond dealers at all.

Table 4: Effects of Changes in Rating on Changes in Credit Spreads

Full Period (April 1, 1997–January 31, 2005)

Maturities	Rating Groups	Rating Changes									
		Rating Up			Rating Down						
		+3	+2	+1	-1	-2	-3	-5	-6	-10	-11
Short	Investment	-0.416	-0.014	-0.015	0.025	0.012	0.384	-	-	-	-
		(0.028)	(0.003)	(0.009)	(0.006)	(0.046)	(0.122)	-	-	-	-
	Speculative	-0.125	-0.005	-0.022	0.736	0.410	0.067	6.791	6.590	-	-
		(0.052)	(0.005)	(0.027)	(0.028)	(0.049)	(0.185)	(0.364)	(0.354)	-	-
Middle	Investment	-0.643	-0.007	-0.010	0.021	0.075	0.038	-	-	-	-
		(0.015)	(0.001)	(0.001)	(0.002)	(0.005)	(0.020)	-	-	-	-
	Speculative	-	-0.081	-0.025	0.288	0.350	1.368	7.153	6.833	0.022	0.014
		-	(0.012)	(0.015)	(0.017)	(0.031)	(0.243)	(0.248)	(0.244)	(0.005)	(0.005)
Long	Investment	-	-0.010	-0.002	0.001	0.035	0.040	-	-	-	-
		-	(0.001)	(0.001)	(0.001)	(0.002)	(0.008)	-	-	-	-
	Speculative	-	-	-0.025	0.052	0.117	3.110	5.272	5.299	-	-
		-	-	(0.006)	(0.044)	(0.010)	(0.516)	(0.558)	(0.531)	-	-
Ultra-long	Investment	-	-0.027	-0.043	0.024	0.013	0.026	-	-	-	-
		-	(0.002)	(0.009)	(0.002)	(0.004)	(0.008)	-	-	-	-
	Speculative	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-

1. The results are based on fixed effect estimation of equation (3) during the period between April 1, 1997 and January 31, 2005.
2. The number in a parenthesis is a robust standard error of a fixed effect estimate. The reported standard error based on Arellano (1987) is robust with respect to cross-sectional heteroskedasticity and within-issue serial correlation.
3. For estimation of speculative grades, the sample period between August 5, 2002 and September 20, 2002 is excluded because bid/ask prices of speculative grades were not quoted by corporate bond dealers at all.

Table 5: Effects of Macroeconomic and Market Liquidity Factors on Credit Spreads

Full Period (April 1, 1997–January 31, 2005)

Maturities	Rating Groups	Independent Variables								
		Credit Risk Factors				Macro Liquidity Factors				
		$deratio_t^i$	$\log\sigma_t^i$	T_t^i	r_t	$Swap_t$	CBv_t	$JGBv_t$	HPM_t	DIa_t
Short	Investment	0.063	0.051	-0.085	-0.119	0.207	-0.010	0.134	-0.057	-0.030
		(0.002)	(0.011)	(0.003)	(0.012)	(0.042)	(0.006)	(0.014)	(0.005)	(0.001)
	Speculative	1.167	0.338	0.098	-0.150	0.256	-0.707	-0.548	-0.045	-0.040
		(0.021)	(0.054)	(0.014)	(0.040)	(0.080)	(0.045)	(0.060)	(0.031)	(0.004)
Middle	Investment	0.106	0.112	0.290	-0.051	0.190	-0.030	0.033	-0.002	-0.019
		(0.001)	(0.008)	(0.007)	(0.002)	(0.005)	(0.002)	(0.003)	(0.002)	(0.0002)
	Speculative	1.1143	0.109	1.786	-0.151	0.262	-0.293	-0.153	-0.018	-0.042
		(0.016)	(0.028)	(0.123)	(0.021)	(0.056)	(0.035)	(0.043)	(0.024)	(0.003)
Long	Investment	0.106	0.014	0.559	-0.062	0.276	-0.017	0.054	-0.006	-0.018
		(0.002)	(0.009)	(0.024)	(0.002)	(0.006)	(0.003)	(0.003)	(0.002)	(0.0003)
	Speculative	0.308	0.076	0.067	0.017	0.262	-0.062	0.213	0.216	-0.063
		(0.012)	(0.028)	(0.486)	(0.023)	(0.065)	(0.054)	(0.055)	(0.035)	(0.003)
Ultra-long	Investment	0.192	0.048	-0.280	-0.104	0.363	-0.013	0.032	-0.050	-0.009
		(0.002)	(0.011)	(0.015)	(0.002)	(0.006)	(0.002)	(0.003)	(0.002)	(0.0003)
	Speculative	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-

1. The results are based on instrumental variable estimation of equation (4) with fixed effects during the period between April 1, 1997 and January 31, 2005. Instrumental variables include constants, $deratio_{t-1}^i$, $deratio_{t-2}^i$, $\log\sigma_t^i$, T_t^i, r_t, $Swap_t$, CBv_t, $JGBv_t$, HPM_t, DIa_t, and quarterly time dummy variables.
2. The number in a parenthesis is a robust standard error of a fixed effect estimate. The reported standard error based on Arellano (1987) is robust with respect to cross-sectional heteroskedasticity and within-issue serial correlation.
3. For estimation of speculative grades, the sample period between August 5, 2002 and September 20, 2002 is excluded, because bid/ask prices of speculative grades were not quoted by corporate bond dealers at all, thereby credit spreads on speculative grades are missing between the two.

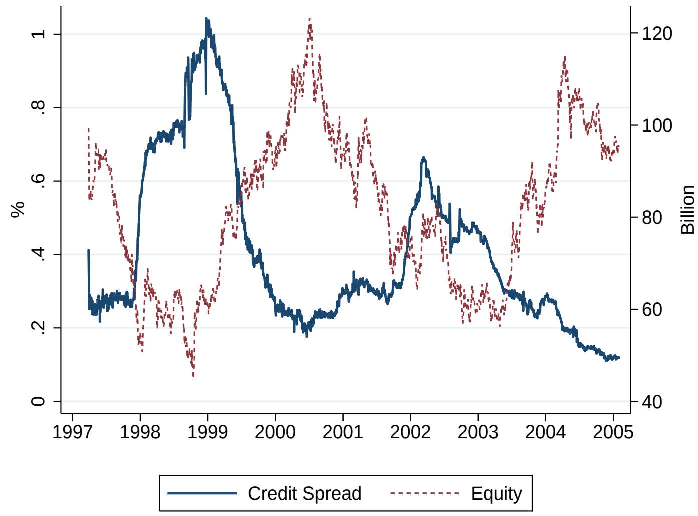

Figure 1. Credit Spreads and Equity Valuation: A-grade Bonds.
The figure plots the average credit spreads on corporate bonds rated as A by Moody's, and the average total equity valuation of corresponding issuing firms.

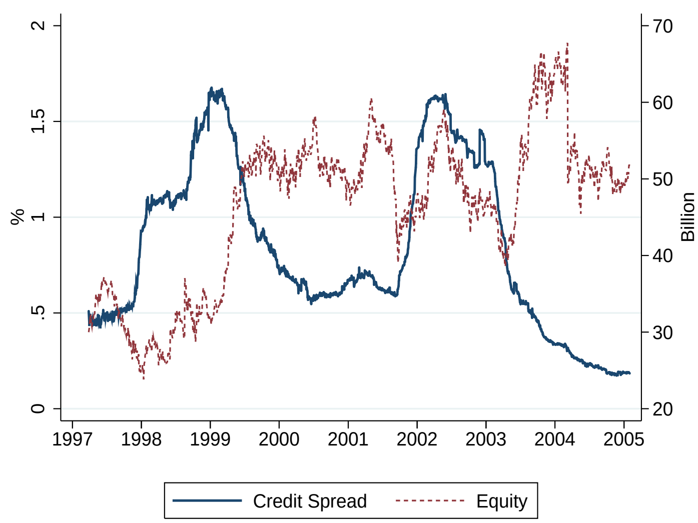

Figure 2. Credit Spreads and Equity Valuation: Baa-grade Bonds.
The figure plots the average credit spreads on corporate bonds rated as Baa by Moody's, and the average total equity valuation of corresponding issuing firms.

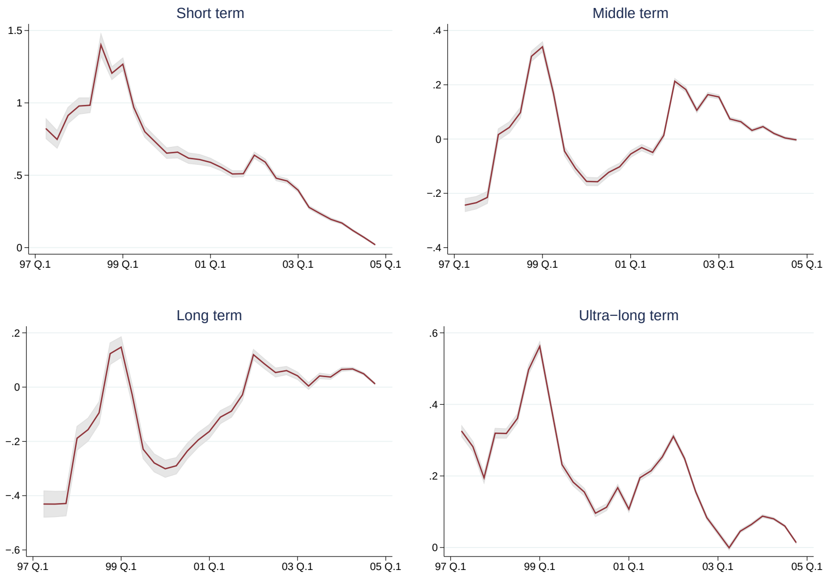

Figure 3. Market-wide Effects for Investment-grade Bonds. The shaded area represents 95% confidence intervals of estimated coefficients on quarterly time dummies (λ_t) of equation (2).

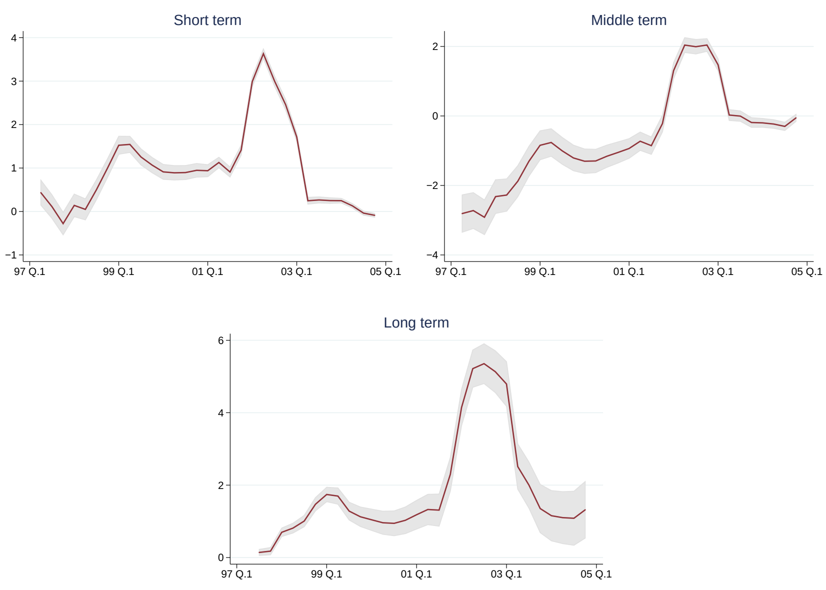

Figure 4. Market-wide Effects for Speculative-grade Bonds. The shaded area represents 95% confidence intervals of estimated coefficients on quarterly time dummies (λ_t) of equation (2).

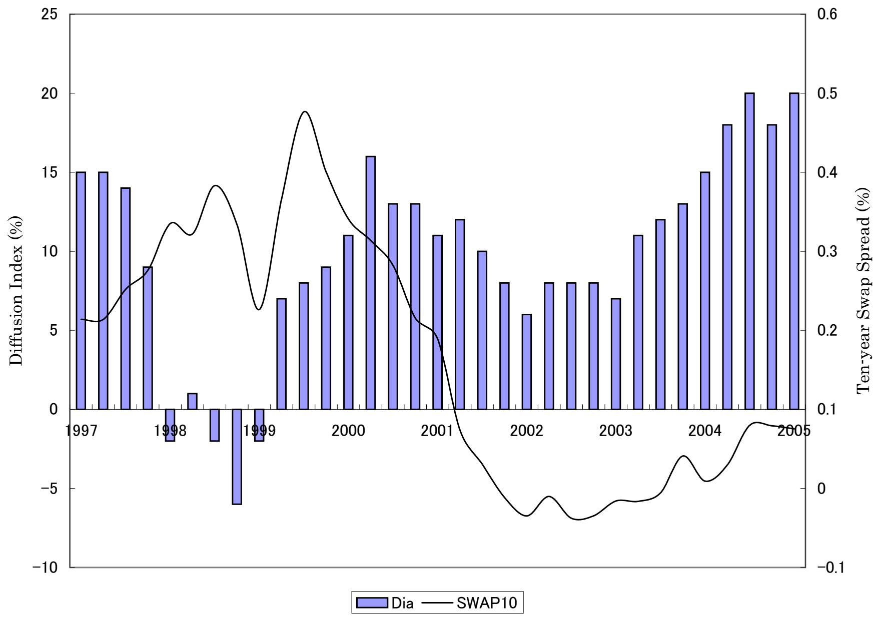

Figure 5. Ten-year Swap Spread and Diffusion Index for Financial Position.

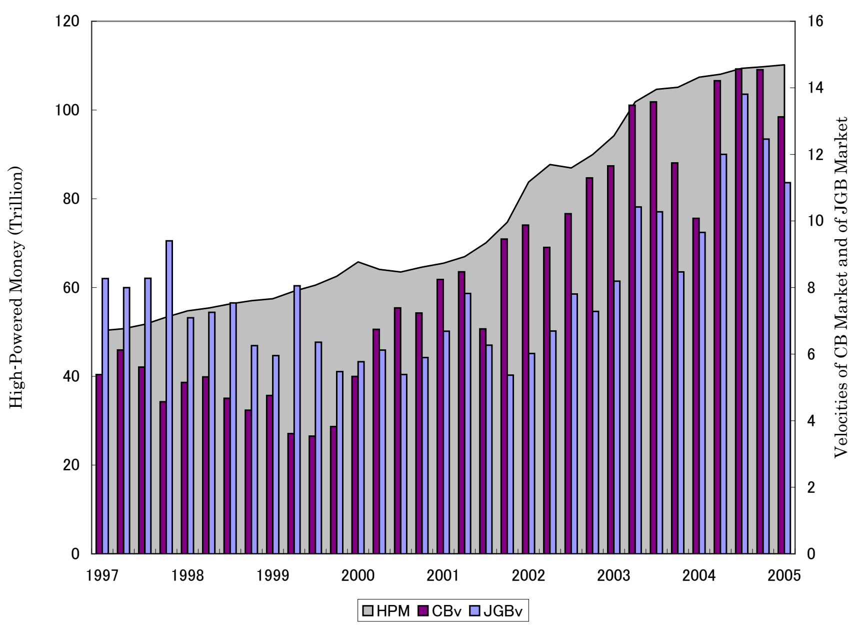

Figure 6. High-powered Money, Velocity of Corporate Bond Market, and Velocity of Japanese Government Bond Market.

Velocity measures for corporate bond market and for Japanese government bond market are defined by CBv $= CBv_t \times 100$ and JGBv $= JGBv_t \times 10$, respectively.