Information-Based Trading in the Junk Bond Market

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Abstract

Taking advantage of a unique corporate bond transaction dataset from the National Association of Securities Dealers (NASD), this paper investigates whether information-based trading takes place in the high-yield corporate bond market, and how firm-specific information flow across related securities, including stocks, options and corporate bonds. Differing from previous studies, I find that current corporate bond returns have explanatory power for future stock price changes. This implies that informed investors do trade in the corporate bond market, and both the stock market and the corporate bond market serve important roles in disseminating new information. The option market, however, contains valuable information about future movements in both stocks and corporate bonds, and these relations are unidirectional, suggesting that the option market is a preferred venue for informed trading. Furthermore, there is strong evidence that informed trading in the option market is distributed across different strike prices, with at-the-money options attracting investors who posses mild firm-specific information, and deep out-of-the-money options catching the attention of those who obtain extreme information.

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Key-words: Firm Specific Information, Information-based Trading, Information-risk Premium, Insider Trading, Junk Bonds, Market Microstructure, Price Discovery.

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1. Introduction

Since 1934, when the United States Congress enacted the Securities Exchange Act, the stock and the options markets have been under intense scrutiny for potential abuse of material nonpublic information. However, information-based trading also seems to be taking place in the corporate bond market, as investigations by the Securities and Exchange Commission (SEC) and the U.S. Attorney's Office have revealed the occurrence of insider trading and price manipulation in the junk bond[1] market by the "king of junk bonds"— Michael Milken. In 1989, James Dahl, an employee of Milken's junk bond department, swore before a grand jury that Milken advised him to buy up Caesar's World bonds from their own customers on the day when Milken made a presentation to Caesar's World on how to handle their finance, i.e., a sales pitch. In 1990, Michael Milken pleaded guilty to six felony counts in connection with insider trading, and he was sentenced by federal Judge Kimba Wood to 10 years in prison (though he was released in 1993).

Michael Milken is not the only one who acted inappropriately on private information in the once arcane world of high-yield debt market. Institutional investors and investment bankers who trade high-yield corporate bonds every so often participate in syndicated loans for the same company issuing high-yield bonds. Since investors who lend to the company are entitled to send representatives to regular meetings with the borrowing company's management and bankers, they obtain access to some confidential information, such as updated projections of revenues and earnings, or plans for an acquisition or divestiture, which public investors will never see. When such information from internal discussions is improperly leaked or misused, prices of the borrowing company's bonds will be affected and investors acting on this private information will make profits. Indeed, trading based on such private information in the credit markets has been warned about in research work authored by Chris Dialynas, a managing director and portfolio manager at Pacific Investment Management Co., which is one of the world's top bond investors. Furthermore,

[1] A bond rated BB or lower because of its high default risk. Also known as a high-yield bond, or speculative bond.

former SEC chairman Arthur Levitt stated that the SEC has "found anecdotal evidence of the possible misuse of inside information in the high-yield (debt) market[2]".

At a first glance, it is counter-intuitive that investors with private information about a company will trade in its debt securities. Even though the value of a company's debt, equity and its derivatives will all be affected by information related to the issuing company's underlying assets, investors who posses such undisclosed information will presumably trade in the equity security and/or its derivatives, rather than in the debt securities. According to a recent study released by the SEC [Edwards, Harris and Piwowar (2004)], average transaction costs for trades in corporate bonds are higher than in stocks. Furthermore, unlike options, corporate bonds do not provide higher leverage than stocks. If trading corporate bonds incurs higher transaction costs but offers lower leverage, why would an informed investor trade in the corporate bond market?

Several explanations stand out when we look into the transaction costs argument and the market structure for high-yield corporate bonds. First of all, as it has been documented in several previous studies, the value of high-yield corporate debt is very sensitive to firm-specific information, especially extreme information regarding the state of the company. Therefore, the high-yield corporate bond market offers potential profitable opportunities for trading on nonpublic information. More importantly, these opportunities provide an additional venue for an informed trader to strategically exploit his private information. Conventionally, an informed trader employs optimal trading strategies in the stock and the options markets to make the most out of his information. These trading strategies typically include certain trading intensity over multiple trading periods, as well as an optimal order size for each individual period [see for example, Kyle (1984, 1985), Foster and Viswannathan (1993) and Holden and Subrahmanyam (1992)]. Conceivably, trading too

[2] See speech by SEC Chairman Arthur Levitt: "The Importance of Transparency in America's Debt Market", at the Media Studies Center, New York, N.Y., on September 9th, 1998.

aggressively on the private information in stocks and options makes it harder for the informed trader to hide from the marker maker and the regulators, and hence increases his transaction costs. As the informed trader becomes more aggressive, trading in stocks and options gets more and more expensive. At some point, the marginal cost from trading an additional amount of stocks and options exceed that for a first trade in high-yield bonds. As a result, substituting a certain amount of excess trading in stocks and options with a trade in the issuer's high-yield debt might better serve the informed trader's goal in maximizing his total profits. Furthermore, given the fact that the debt securities market has been subject to much less scrutiny for insider trading compared to the markets for equity securities and derivative securities, informed traders have much lower perceived probability of being detected and prosecuted. Consequently, to take full advantage of his private information, the informed trader will choose to trade a certain amount of high-yield bonds, in addition to some quantity of stocks and options of the issuer.

In addition to higher transaction costs from more aggressive trading in stocks and options, there are other important factors that play a role in encouraging an informed trader's decision to trade in the junk bond. These factors include some common practices within the bond industry, and the trader's degree of risk aversion. First, differing from the equity market, the high-yield corporate debt market is largely institutional. Institutional investors who trade high-yield corporate bonds sometimes buy syndicated loans for the same company issuing high-yield bonds. In addition, these investors in syndicated loans are often also traders, who trade bank loans next to high-yield bonds. In fact, it is quite often that a single trader at a hedge fund deals in all of a company's debt instruments. Under such porous circumstances, keeping private information private and avoiding improper use of this information is a challenge. "You can't put a Chinese wall through someone's head," says Michael Kaplan, a partner in the corporate practice at law firm Davis Polk & Wardwell[3].

[3] For further discussion of insider trading in the bond market, see a recent article by Carolyn Sargent: "The New Insider Trading?" Investment Dealers' Digest, October 31st, 2005.

Second, for some risk averse investors, even if they have access to some information about a pending large change in the firm's asset value, they might choose to trade in bonds to stay away from down-side risk, as their aversion to risk cannot be fully eliminated by the piece of information they have, especially when they are not so sure about the quality of the information. While it is true that the down-side risk can be easily hedged in the options market, associated transaction costs might render direct trading in bonds a better choice.

If an informed trader trades corporate bonds as well as stocks and options, new information will be disseminated in all three related markets. Thus, current bond prices hypothetically contain valuable information about future price movements in the stock and options markets. Taking advantage of a unique corporate bond transaction dataset for a set of 50 most frequently traded high-yield corporate bonds from NASD, this paper empirically tests this hypothesis and explores the dynamics of information flow across related markets by examining the pair-wise lead-lag relations between stocks, corporate bonds and options. Differing from previous studies, I find that current high-yield corporate bond price changes have explanatory power for future stock returns. This implies that the bond market serves an important role in disseminating new information. The option market, however, contains valuable information about future movements in both the stock and the bond market, and these relations are unidirectional, suggesting that the option market is a preferred venue for informed trading. Furthermore, there is strong evidence that informed trading in the option market is distributed across different strike prices, with at-the-money options attracting investors who posses mild firm-specific information, and deep out-of-the-money options catching the attention of those who obtain extreme information.

The rest of the paper is organized as follows. Section 2 summarizes some recent developments in the corporate bond over-the-counter (OTC) market and the new Trade Reporting and Compliance Engine (TRACE) introduced by NASD. The stock, bond and options data are described in Section 3. Section 4 investigates pairwise lead-lag relationships between stocks, bonds and options. Whether these relationships are subject to infrequent trading in bonds and how they vary with firm size are addressed in Section 5. Section 6 concludes and points out some possible extensions.

2. The Corporate Bond Market and NASD's TRACE

The corporate bond market assumes roughly as important a role in corporate financing as the equity market, with approximately $4.4 trillion outstanding in 2004, which is larger than both the US treasury market ($3.8 trillion outstanding) and the municipal bond market ($2.0 trillion outstanding)[4]. The stock market is larger at about $15 trillion[5]. The total dollar volume of the bond market in 2003 is about $10 trillion, more than the trading volume on the NYSE[6]. About $18 billion in par value of corporate bonds turns over in roughly 22,000 transactions on a typical day[7]. As baby-boomers age and shift more of their assets from equity investments to debt investments, the corporate bond market will certainly grow in both size and importance.

However, transparency in this market has never been comparable to that of other securities markets. As Doug Shulman (NASD's President of Markets) said, the corporate bond market 'has been largely a mystery to retail investors'. Following insider trading and price manipulation scandals in the corporate bond market in the late 1980's, the opaqueness of the corporate fixed-income market, especially that of the high-yield bond market, became a really big concern for the U.S. Congress and the SEC. The Fixed Income Pricing System (FIPS) was the result of discussions between the SEC and the NASD on how to increase the transparency of the junk bond market. FIPS helps regulators effectively monitor trading in high-yield debt. On

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4 NASD News Release, March 26th, 2004.

5 Business Times, Feb 8th, 2005

6 The Economist, Oct 14th, 2004

7 See a speech by Doug Shulman, NASD's President of Markets, on February 2nd, 2005 in New York, New York, 'Bond Market Association Legal and Compliance Conference Keynote Address', which is on the NASD's website.

April 11th, 1994, The Nasdaq Stock Market, Inc., began operation of FIPS for members trading high-yield bonds. Under the FIPS system, NASD members are required to report all secondary market transactions on a selected set of high-yield bonds within 5 minutes of execution. Based on submitted transaction reports, hourly price and volume data on about 50 most frequently traded high-yield bonds are displayed on the FIPS terminal. Even though FIPS brought some transparency to the high-yield debt market, the corporate debt market as a whole still does not live up to regulators' expectation of a transparent market. In 1998, former SEC Chairman Levitt noted that "[t]he sad truth is that investors in the corporate bond market do not enjoy the same access to information as a car buyer or a homebuyer or, dare I say, a fruit buyer." In order to further increase the transparency of the corporate bond markets, NASD initiated a broader system know as TRACE (Trade Reporting and Compliance Engine) on July 1st, 2002, which incorporated the previous FIPS system. Under TRACE rules[8], all NASD members were obligated to submit transaction reports for any secondary market transaction in TRACE-eligible securities[9] between 8:00PM and 6:30PM (EST) within one hour and fifteen minutes of the time of execution[10]. Transaction information on TRACE-eligible securities which are investment grade[11] and have an initial issuance of $1 billion or higher is subject to immediate dissemination. Additionally, 50 Non-Investment grade and most actively traded TRACE-eligible securities (TRACE 50 thereafter) are designated for

8 Also known as the NASD Rule 6200 Series.

9 According to NASD Rule 6210(a), TRACE-eligible security 'mean all United States dollar denominated debt securities that are depository eligible securities under Rule 11310(d); Investment Grade or Non-Investment Grade; issued by United States and/or foreign private issuers; and: (1) registered under the Securities Act of 1933 and purchased or sold pursuant to Rule 144A of the Securities Act of 1933.' It does not include debt securities issued by government-sponsored entities (GSE), mortgage-backed or asset-backed securities, collateralized mortgage obligations and money market instruments.

10 For a detailed description of TRACE rules and their subsequent amendments, please refer to NASD Notice to Members NtM-02-76, NtM-03-12, NtM-03-22, NtM-03-36, NtM-03-45, NtM-04-39 and NtM-04-65.

11 Rated by a nationally recognized statistical rating organization (NRSRO) in one of its four highest generic rating categories. See NASD Rule 6210(h).

dissemination. In the subsequent two and half years, major improvements to the TRACE system have focused on increasing dissemination and reducing reporting time. As of July 1^{st}, 2002, only 540 securities are subject to dissemination. This number went up to 4,500 after NASD began distributing information on a third group of Investment Grade TRACE-eligible securities that are rated 'A3' or higher by Moody's or 'A-' or higher by S&P and have a $100 million or higher original issue size on March 3^{rd}, 2003, and another group of 120'Baa/BBB' rated bonds on April 14^{th}, 2003. After another two-stage implementation of the amendments to the TRACE Rules, which were approved by SEC on September 3^{rd}, 2004, NASD started full dissemination of transaction information on all TRACE-eligible securities except those Section 4(2)/Rule 144A TRACE-eligible securities. Currently about 29,000 corporate bonds, another jump from 17,000 as of October 1^{st}, 2004, have their transaction and price data spread to the market in real-time, and the corporate bond markets have never before been so transparent. Meanwhile, the time to report a trade of a Trace-eligible security has been declining. Starting from 75 minutes on July 1^{st}, 2002, the reporting period went down to 45 minutes on October 1^{st}, 2003 and further down to 30 minutes on October 1^{st}, 2004. It was shortened to just 15 minutes on July 1^{st}, 2005.

TRACE improves on FIPS in several important ways. First, FIPS only covered non-convertible, non-investment grade and publicly offered debt which is not part of a medium-term note program[12], and only a set of 50 most actively traded bonds were subject to dissemination. However, under TRACE rules, transaction information for any secondary market transaction in all TRAC-eligible securities are required to be reported to NASD, and starting February 7^{th}, 2005, NASD has begun to fully disseminate transaction information on the entire universe of corporate bonds, which is considered by NASD as the most significant innovation for retail bond investors in decades. Second, for each debt security that is subject to dissemination, TRACE dramatically increase the amount of information distributed to the public. FIPS only published hourly summaries on the prices and total volume of transaction in a set of

12 Nasdaq Stock Market, Inc., 1997, Rule 6210(i).

50 bonds, while transaction and price data on each trade in TRACE-eligible securities are distributed to the market.

3. Data

The transaction dataset for TRACE 50 high-yield bonds contains execution date and time (recorded to the second), price, yield, quantity, and some other information that can be used to purge invalid transaction reports for every trade from July 1st, 2002 to September 30th, 2004[13]. The TRACE 50 bonds are chosen by the NASD advisory committee based on criteria such as the security's volume, price, name recognition, amount of research attracted, a minimum amount of bonds outstanding, number of dealers that are making a market in this security and the security's contribution to the TRACE 50's industry diversity. Similar to FIPS 50, the TRACE 50 are characterized by high trading volume, both in terms of number of transactions and number of block size trades, and similar trading patterns to the issuer's stock. Over time, bonds with small trading volume were replaced with more active bonds. Transaction information on the first TRACE 50 bonds was released to the market on real-time basis for about one year since July 1st, 2002. Beginning on July 13th, 2003, the TRACE 50 list was updated every 3 month until September 30th, 2004. During this time period (July 1st, 2002 to September 30th, 2004), 177 high-yield bonds from 135 issuing firms were included in the TRACE 50 lists for dissemination.

Daily closing stock price and related options quotes data for the issuing firms are obtained from OptionMetrics INC for the period from July 1st, 2002 to April 15th, 2004. Only 129 bonds from 110 firms are subject to dissemination during this period. Since some companies are not public, and some are traded on the OTC market or the pink sheet market, stock price data do not exist for 18 of these firms. This reduces the sample to 92 firms. Furthermore, 15 out of the 92 firms do not have options traded on

13 On October 1st, 2004, NASD started its second stage dissemination, and many more high-yield bonds are subject to dissemination. The concept of TRACE 50 does not exist any more.

their common stock during this period. By excluding these 15 firms from my sample, I was left with 77 firms with 111 bonds.

To avoid potential bias from non-synchronous trading, a daily time series dataset is formed by keeping the transaction price for the last valid trade before 4:00PM (EST) for each of these 111 bonds. As several firms have multiple bonds included in TRACE 50 list during certain periods of time, only the most active bond with the highest priority in payments is kept for inter-market analysis[14]. As a result, a panel of daily stock, bond and options data for 77 firms is employed for this study.

Table 1 contains summary characteristics for the 77 corporate bonds and their issuing firms at the time of their initial entry to the TRACE 50 list. Issuing firms are fairly large with median total asset value of 11471.1 million USD and characterized by high financial leverage, which is consistent with low credit ratings of these bonds. Also consistent with the high-yield nature, many bonds in the sample contain embedded options. Of the 77 bonds, 38 (49.35%) are callable prior to maturity and 14 (18.18%) are convertible. The bonds included in this study represent 7 different industries and they are concentrated in Manufacturing (38.96%), Servicing (31.17%) and Energy (11.69%). About half of the 77 bonds are senior unsecured notes. Senior notes and subordinated notes account for another 30 percent of the sample. Coupon payments are made twice per year for each of the 77 bonds, and all are fixed plain vanilla coupons, except for one bond which has a variable coupon size. The average coupon rate is 7.48%. About 80% of the TRACE 50 bonds are rated no lower than B- by S&P and none of them defaulted during the sample period.

The use of option quotes data, instead of transaction data, deserves some comments. Information-based market microstructure models demonstrate that the bid-ask spread reflects a balancing of losses to the informed traders with gains from the uninformed traders and therefore contains information about the probability of trading on private

14 Examining the price behavior of different bonds issued by the same firm is another interesting topic for future research.

information in the market [See Copeland and Galai (1983), Glosten and Milgrom (1985) and Easley and O'Hara (1987, 1992)]. In addition, as shown by Chan, Chung and Fong (2002), because of generally larger bid-ask spread in the option market, as documented by Vijh (1999), informed traders might have an incentive to submit limit orders instead of market orders, and hence quote revisions contain valuable information about future market movements. Moreover, since corporate bonds embed a short position in puts on the value of the firm, call option data are eliminated from the sample. Finally, as will be shown in the next section, ATM options and OTM options carry different information about future movements in stocks and bonds. Therefore, both ATM and deep OTM put option spreads are kept for each firm.

4. Inter-Market Relationships between Stocks, Bonds and Options

If new information about the value of an individual firm exists in the market, it should be reflected in the prices of the firm's stock and options, as well as its bonds. This section provides a comprehensive examination of pair-wise relationships between stocks, bonds and options. Daily stock returns, $SR_{i,t}$, and daily bond returns, $BR_{i,t}$, are calculated using the end-of-day closing prices. For the options market, normalized spreads for both ATM and deep OTM puts are calculated by dividing the bid-ask spread by the midpoint of bid and ask quotes. These are denoted as $AS_{i,t}$ and $OS_{i,t}$ respectively.

In order to isolate interest rate risk, for each individual corporate bond I construct a corresponding default-free bond whose future cash flows match those of the corporate bond perfectly. The price of default-free bonds can simply be calculated by discounting the cash flows at corresponding default-free zero-coupon interest rates. These zero-coupon rates are estimated by employing a modified version of the extended Nelson-Siegel model [Bliss (1997)] on the observed on-the-run Treasury curve[15]:

15 Hotchkiss and Ronen (2002) calculate these default-free zero-coupon rates by using a method proposed by Fisher, Nychka, and Zervos (1994). However, based on a series of parametric and

$$\min_{\beta_0, \beta_1, \beta_2, \tau_1, \tau_2} \sum_{i=1}^{N_t} (w_i \varepsilon_i)^2,$$

subject to

$$r(m_{\min}) \geq 0,$$

$$r(m_{\max}) \geq 0,$$

and

$$\exp[-r(m_k)m_k] \geq \exp[-r(m_{k+1})m_{k+1}], \ \forall m_{\min} \leq m_k < m_{\max},$$

where

$$w_i = \frac{1/d_i}{\sum_{j=1}^{N_t} 1/d_j},$$

$$r(m) = \beta_0 + \beta_1 \left[\frac{1 - e^{-m/\tau_1}}{m/\tau_1} \right] + \beta_2 \left[\frac{1 - e^{-m/\tau_2}}{m/\tau_2} - e^{-m/\tau_2} \right],$$

$$\hat{p}_i = \sum c_{i,m} e^{-r(m)m},$$

and

$$\varepsilon_i = p_i - \hat{p}_i.$$

In this model, m represents time to maturity, $r(m)$ is the discount rate for coupon or principal payments at time m, d denote Macaulay duration, and c refers to cash flows. Based on the prices of the constructed default-free bonds, their returns, $DR_{i,t}$, can be readily calculated. Furthermore, to control for the effect of market-wide information, I include the S&P 500 index return, denoted as $MR_{t,}$ in the model. Data for both the observed on-the-run Treasury curve and the S&P 500 index return are retrieved from the Center for Research in Security Prices (CRSP).

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nonparametric tests, Bliss (1997) compares five distinct term structure estimation methods, including the smoothed and unsmoothed Fama-Bliss methods, the McCulloch model, the Fisher-Nychka-Zervos method and the extended Nelson-Siegel model, and concludes that the Fisher-Nychka-Zervos method does almost always poorly relative to the other four alternatives, in terms of both in-sample goodness-of-fit and out-of-sample performance.

4.1 The Empirical Model

To examine whether information-based trading takes place in the corporate bond market, the following panel Vector Auto-Regression (VAR) model with two controlling variables is estimated. Based on this model, Granger causality tests are conducted to identify pairwise lead-lag relationships between stocks, bonds and options:

$$Y_{i,t} = \mathrm{A} + \sum_{j=1}^{J} B_{-j} Y_{i,t-j} + C_t X_t + E_{i,t} \ ,$$

where

$$Y_{i,t} = [SR_{i,t}, BR_{i,t}, AS_{i,t}, OS_{i,t}]',$$

$$X_t = [MR_t, DR_t]',$$

$$A = [\alpha_1, \alpha_2, \alpha_3, \alpha_4]',$$

$$B_{-j} = \begin{bmatrix} \beta_{11,-j} & \beta_{12,-j} & \beta_{13,-j} & \beta_{14,-j} \\ \beta_{21,-j} & \beta_{22,-j} & \beta_{23,-j} & \beta_{24,-j} \\ \beta_{31,-j} & \beta_{32,-j} & \beta_{33,-j} & \beta_{34,-j} \\ \beta_{41,-j} & \beta_{42-j,} & \beta_{43-j,} & \beta_{44,-j} \end{bmatrix} \ ,$$

$$C = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \\ \gamma_{31} & \gamma_{32} \\ \gamma_{41} & \gamma_{42} \end{bmatrix},$$

and

$$E_{i,t} = [\varepsilon_{i1,t} \quad \varepsilon_{i2,t} \quad \varepsilon_{i3,t} \quad \varepsilon_{i4,t}]'.$$

A, B and C contain parameters to be estimated, and E_t is the error vector. This model is estimated by generalized least squares (GLS) with error terms corrected for auto-correlation.

As individual corporate bonds tend to be less frequently traded than their corresponding stocks and options, even for TRACE 50 which are considered more active than other high-yield bonds [Hotchkiss and Nolen (2002)], this model is first estimated with data on 48 firms with relatively high bond volume to mitigate potential bias introduced by infrequent trading. Table 2 contains summary statistics about characteristics of the 48 bonds and their issuing firms.

4.1.1 Bond-stock relationships

According to the structural firm-value approach to the valuation of corporate debt (Merton (1974)), corporate bonds can be viewed as risk-free debt combined with a short position in a put on the value of the firm's assets. Since equity can be considered a call option on the assets, if financial markets are efficient, stock and bond prices should move simultaneously with no lead-lag relationship, and the direction of contemporaneous movements should reveal the nature of information in the markets: information about the mean value of the issuing firm's assets leads to positive correlation between stock and bond returns, while information related to changes in the volatility of the firm's asset returns causes negative correlation.

Due to the lack of adequate corporate bond data, few studies have empirically examined the stock-bond relationship. Early research on the stock-bond linkages has been conducted on the aggregate level, looking at low-grade bonds [Blume, Keim and Patel (1991), Cornell and Green (1991)]. While both Cornell and Green (1991) and Blume, Keim and Patel (1991) find that speculative bonds are very sensitive to stock price movements, neither study is able to identify a significant impact of previous or future stock returns on current corporate bond returns. As the corporate bond market has become more transparent, two studies in the literature have explicitly examined the lead-lag relationship on the individual firm level. However, their results are contradictory. Using weekly quotes data from Merrill Lynch, Kwan (1996) finds that lagged stock returns have explanatory power for current bond yield changes, but not vice versa. Based on this finding, he concludes that 'stocks lead bonds in reflecting firm-specific information'. In contrast, Hotchkiss and Ronen (2002) analyze a transaction dataset for 55 high-yield bonds included on the NASD Fixed Income

Pricing System (FIPS)[16] and reject the hypothesis that stocks lead bonds in reflecting firm-specific information. Instead, they argue that no causal stock-bond relationship exists, and the observed contemporaneous correlation between stock and bond returns only reveals their joint reaction to common factors.

Consistent with Kwan (1996) and Hotchkiss and Ronen (2002), I find stock returns are positively correlated with contemporaneous bond returns with a correlation coefficient of 0.154, suggesting that at the individual firm level, information that drives individual stock and bond returns is primarily related to the mean value of the firm's asset, not the volatility of asset returns. Also consistent with Blume, Keim and Patel (1991) and Cornell and Green (1991), high-yield bonds are not sensitive to movements in interest rates (as the coefficient for DR_t is not significant) but are very sensitive to changes in stocks prices. The coefficient for MR_t is 0.1081, and is significant at 5% level.

As to the leads and lags, Table 4 shows that lagged stock returns have explanatory power for current bond returns, with the coefficients significant at 1% level back to day t-5. Furthermore, Granger causality test rejects the null hypothesis that the coefficients for SR_{t-1} through SR_{t-5} are zero at 1% level. Therefore, there is strong evidence that the stock market contains valuable information about future bond returns. This result is consistent with the stock lead found in Kwan (1996).

What differentiates my study from previous ones is the finding that current stock returns are positively correlated with lagged bond returns (Table 3). Coefficients for lagged bond returns are both economically and statistically significant, not only for day t-1, but for day t-2 and day t-3. The F-value for testing that $\beta_{12,t-j}$ equals zero for j=1, 2, 3, 4 and 5 is 3.9121, significant at 1% level. This empirical result, together with the anecdotal evidence introduced above, confirm my claim that information-based trading also takes place in the high-yield corporate bond market.

16 For more detailed information about FIPS, see the NASD NtM 94-23, Alexander, Edwards, and Ferri (1999, 2000), and Hotchkiss and Ronen (2002).

The reason that this relationship is not found in Kwan (1996) might be attributed to the quality of the data he uses. First, it is hard to identify active bonds using quotes data from a dealer, even though small issues that are subject to infrequent trading are eliminated from the sample. In fact, the use of inactive bonds to examine the lead-lag relations might bias his results toward the stock lead. Second, since information (especially publicly released information) is impounded into prices quickly, using data on weekly frequency to address the price discovery process is also questionable.

It is intriguing to notice that my results differ completely from those of Hotchkiss and Ronen (2002), as the quality of FIPS data they use is close to the TRACE 50 data in the current study. However, a closer look into their methodology reveals serious problems. In order to answer the question "Do stocks lead bonds in reflecting firm-specific information?", Hotchkiss and Ronen (2002) "construct a portfolio of the 20 most actively traded FIPS bonds which also have publicly traded equity", and conduct an analysis of Granger causality "between portfolios of the FIPS bonds and of the corresponding stocks". Since aggregation across different bonds and stocks into portfolios will remove valuable information about informed trading in stocks and bond at the individual firm level, unless there is trading based on portfolio or market related information, it is hard to identify any lead-lag relations between stocks and bonds. Not surprisingly, Hotchkiss and Ronen (2002) conclude that stock returns do not Granger cause bond returns, nor the other way around.

Moreover, the evidence that both lagged stock returns and lagged bond returns predict current prices movements implies that it takes time for new information to become incorporated into security prices. Compared to the corporate bond market, the stock market is informationally more efficient. According to the results reported in Table 3, lagged stock returns only for time t-1 is statistically significant at the 5% level, and the magnitude drops dramatically after time t-1, while lagged bond returns are statistically significant for both time t-1 and t-2, with even much higher magnitude for time t-2. This indicates that information gets impounded in stock prices within one day, while it takes the corporate bond market much longer to adjust to the new information, a conclusion that differs from Hotchkiss and Ronen (2002) where they argue that market quality is no poorer for bonds than for their underlying stocks.

To summarize, even though the stock market and the bond market differ in degree of informational efficiency, an informed trader trades in both the stock market and the high-yield corporate bond market on their private information, and both markets serve important informational roles in the price discovery process.

4.3.2 Bond-option relationships

Compared to a small body of work on the stock-bond interrelation, literature on whether the corporate bond market also contains important information as to future movements in the option market is literally blank. Following Beckers (1981), who suggests that ATM options contain most of the relevant information in predicting future market volatility, most empirical studies on the links between options and equity markets focus on data for at- and near-the-money options. Chakravarty, Gulen and Mayhew (2004) find that on average, the information share of the price discovery process tends to be higher for OTM options than ATM options. Furthermore, as corporate bonds embed a short position in OTM put options on credit risk, it is very natural to check the OTM option market. In this paper, I use the bid-ask spreads in both OTM and ATM put options as a measure of information-based trading on the options market.

Table 4, 5 and 6 establish a very interesting relation between the corporate bond market and the option market. Even though none of the coefficients for lagged deep OTM put spreads are significant in explaining current bond returns (Table 4), Granger causality tests do reject the null hypothesis that lagged OTM spreads, as a whole, have no explanatory power (with an F-value 2.5503 and a significance level of 0.0259). On the other hand, as shown by Table 6, when current deep OTM put option spreads are regressed on lagged bond returns, none of the coefficients are significant at any sensible level. Furthermore, Granger causality tests cannot reject that all coefficients are equal to zero. Therefore, OTM put spreads contain valuable information that can help to predict future bond returns, indicating that investors prefer to trade OTM options rather than high-yield corporate bonds.

The option lead, however, is not confirmed when I examine the relationship between bonds and ATM options. Table 4 shows that lagged ATM put option spreads have no explanatory power for current bond returns. Thefore, if an informed investor obtains some information that will affect the value of both corporate bonds and options, trading OTM options is her first choice. This is because for delta-equivalent positions, deep OTM put options are more subject to a crash in a firm's value than ATM options. As a result, informed traders who obtain very bad news about a firm will prefer to buy OTM puts on the firm's stock, which will be reflected in the bid-ask spreads. On the other hand, since corporate bonds embed a short position in OTM puts, only information about a possible crash in the firm's value, and hence default in future interests and principal payments will affect the bond price. Therefore, the evidence of OTM put option spreads predicting future bond returns indicates that the option market is leading the bond market in reflecting extreme firm-specific information. This explanation from the perspective of the nature of private information can be further strengthened by the lead-lag relations between options and stocks discussed in the following subsection.

4.3.3 Stock-option relationships

To complete the examination of information flow across stocks, bonds and options, I check whether the option market contains valuable information about future stock returns. Following seminal work by Black (1975), there has been a huge literature studying inter-market relationships between equity and equity derivative markets. As suggested by Black (1975), the option market might be more attractive to informed traders than the market for the underlying stock because options offer higher financial leverage, and the option market is characterized by less stringent margin requirements, no uptick rule for short selling, and probably lower transaction costs. Whether the option market is leading the stock market in reflecting new information has been directly examined in numerous empirical studies[17]. Panton (1976) takes the first step in this direction, but he fails to demonstrate conclusively that call options are in general valid predictors of future stock price changes. Based on the Black-Scholes option pricing model, Latane and Rendleman (1976) and Beckers (1981) derive the volatility implied in option prices and show that it predicts future stock price variability. The leading role of the option market is strengthened by Manaster and Rendleman (1982), where they compare the implied and observed stock prices and

17 The stock-option link and the role of the options market in the price discovery process have also been addressed indirectly from many perspectives. Early accounting research shows that current option prices reflect market anticipation of forthcoming earnings announcements and predict future stock price variability [Patell and Wolfson (1979, 1981)]. The informational role of options markets are further investigated in the financial markets literature. Jennings and Starks (1986) find that the stock prices of firms with listed options adjust to earnings announcements faster than those of nonoption firms and they conclude that options markets help to disseminate earnings news. Grossman (1988) argues that option trading reveals the future trading intentions of investors, and therefore helps to predict future price volatility. By comparing return patterns in contemporaneous stock and options, as well as options that are adjusted for contemporaneous changes in the price and volatility of the underlying asset, Sheikh and Ronn (1994) confirm informed trading in options markets. Figlewski and Webb (1993) show that options increase both transactional and informational efficiency of the market for the underlying stocks by reducing the effect of short selling constraints. A less-related literature examines hedging-related effects of option trading and their implications for inter-market linkages. When the complete market assumption under standard option pricing models is relaxed, introduction of options alters investors' hedging opportunities. The value of the underlying stocks increases while excess return volatility declines. This phenomenon has been documented in several empirical studies (Nabar and Park (1988), Skinner (1989), Conrad (1989)) and is subsequently formalized by DeTemple and Selden (1991) in a theoretical model. While most studies confirm the important role of options markets in the general price formation process, two exceptions stand out. Bhattacharya (1987) tries to compare implied bid and ask stock prices, which are derived from options quotes, to observed bid and ask stock prices to identify arbitrage opportunities. He fails to find any profitable trading strategies and hence cannot reject the null hypothesis that option prices bear no additional information over that contained in contemporaneous stock prices. By examining the depth and bid-ask spreads of the Chicago Board Options Exchange (CBOE), Vijh (1990) shows that the options market is not dominated by informed traders.

demonstrate that the implied stock prices contain valuable information about the equilibrium prices of the underlying stocks that has not been revealed in the stock market. Furthermore, Fleming, Ostdiek and Whaley (1996) compare the transaction costs in the stock and the option markets, and show that for individual stocks, price discovery happens in the stock market as it offers lower spreads and higher liquidity. However, Vijh (1988) argues that the result of Manaster and Rendleman (1982) is questionable, since using daily closing prices introduces a bias associated with the bid-ask spread and nonsynchronous trading. After purging the effects of bid-ask spreads, Stephan and Whaley (1990) find that the stock market leads the option market. Nevertheless, Chan et al. (1993) argue that the stock lead is due to the relative smaller stock tick. If the average of the bid and ask is used instead of the transaction price, neither market leads the other.

While most work by middle 90s investigate the price relation between stocks and options, recently studies on the lead-lag relation have been focused more on trading volume[18]. Easley et al. (1998) show that "positive news option volumes" and "negative news option volumes" have predictive power for future stock price changes. The predictive ability of option trading volume is subsequently confirmed by Pan and Poteshman (2003), but not by Chan, Chung and Fong (2002). Cao, Chen and Griffin (2003) find that option volume imbalances are informative in the presence of pending extreme information events, but they fail to identify the same information role for option volume during normal periods. By measuring the relative share of price discovery occurring in the stock and options markets, Chakravarty, Gulen and Mayhew (2004) conclude that informed trading takes place in both stock and option markets, suggesting an important informational role for option volume. Following Chan, Chung and Fong (2002), who suggest that option quote revisions contain

18 Trading volume relations in the stock and options markets have been explored by Anthony (1988) and Stephan and Whaley (1990). While Anthony (1988) finds weak evidence of the option lead based on a daily dataset, Stephan and Whaley (1990) use intraday transaction data and draw an opposite conclusion. However, using total call option volume over a certain period of time is subject to question as its information content is hard to interpret.

information about future price movements, this study uses bid-ask spreads for both ATM and deep OTM options. Consistent with Chan, Chung and Fong (2002), I find an informational role for option quote revisions. Table 3 shows that current stock returns are negatively correlated with ATM put spreads for the previous day, and lagged ATM put option spreads Granger cause current stock returns (F-value of 2.3846, significant at 5% level). Since lagged stock returns have no explanatory power for current ATM put spreads, it is safe to conclude that trading in options leads trading in the underlying stocks, with a one-day lag. This conclusion complements the findings of a one-day lead of options by Manaster and Rendleman (1982) based on transaction price data, and that of Anthony (1988) with volume data. It also supports the argument that informed traders might submit limit orders in the option market to exploit their private information.

Interestingly, the leading role of option quote revisions can not be confirmed by deep OTM options. Lagged deep OTM put spreads do not predict current stock returns (Table 3), nor are lagged stock returns correlated with current OTM spreads (Table 6). This result contradicts that of Chakravarty, Gulen and Mayhew (2004), where they argue the average information share is significantly higher for OTM options than for ATM options. If the higher information share for OTM options in the price discovery process can be attributed to their higher leverage, the superior predictive power of ATM option spreads might reside in their tighter bid-ask spreads compared to OTM options. However, this explanation is not very convincing as informed traders tend to submit limit orders in the option market to avoid higher options spreads relative to those of stocks.

The finding that current stock returns can be predicted by lagged spreads for ATM puts but not OTM puts can be explained by the kind of information investors trade on. Compared to deep OTM put options, ATM puts are more sensitive to changes in the mean value of a firm's assets, especially when the changes are not dramatic. Therefore, unless there is "crash" information about the firm's value, which will change the moneyness of the deep OTM put options, informed traders are more likely to trade ATM options. The clustering of informed trading in ATM options makes

ATM option spreads capable of predicting future stock price changes, leading to the conclusion that the option market is leading the stock market in reflecting mild firm-specific information. The identification of a unidirectional relation of ATM options leading stocks complements the finding that OTM options lead corporate bonds in displaying how an informed trader's choice of options of different moneyness depends on the type of information she possesses. If she has some mild information, she will trade in at-the-money options; however, if she has some extreme information, she will trade in deep out-of-the-money options. This finding contributes to a strand of literature on how information based trading in the option market is allocated across strike prices [De Jong, Koedijk, and Schnitzlein (2001), Kaul, Nimalendran and Zhang (2002), Anand and Chakravarty (2003), Chakravarty, Gulen, Mayhew (2004)].

5. Infrequent Trading and the Lead-Lag Relationships

In this section, the panel VAR model is re-estimated based on data for all 77 firms to examine whether the results in the previous section are subject to infrequent trading in corporate bonds. As shown by Table 1 and Table 2, firms with inactive bonds tend to be smaller than firms with active bonds. Reinserting those small firms and examining the pairwise lead-lag effects allows us to see whether an informed trader's choice to trade high-yield corporate bonds depends on the issuer's size, and how the dynamics of information flow across different securities varies with firm size. The results are presented in Table 7 through Table 10.

Stock returns are still positively correlated with contemporaneous bond returns at 0.143. The explanatory power of past bond returns remains, with $\beta_{12,-j}$ estimated at 0.0403, 0.0852 and 0.0362 respectively for j=1, 2, and 3. All estimates are statistically significant at 5% level except for that of time t-3, which is significant at 10%. In addition, Granger causality tests confirm additional predictive power added by lagged bond returns, with an F-value of 3.8959, which is significant at 1% level. Since higher frequency of trading in stocks as compared to bonds tends to introduce a spurious stock lead, the fact that the predictive ability of previous bond returns for present stock prices changes remains even for firms with inactive bonds makes my results very strong.

The fact that investors might choose to trade on their private information in the corporate bond market has important implications for surveillance for illegal insider trading in this market. While this study does not investigate whether corporate bond traders are trading on insider information unlawfully or aim at establishing a breach of fiduciary duty, it is likely that some of the information that informed traders exploit is illegal in nature. If prices of corporate bonds are sensitive to private information and the market for corporate bonds, especially high-yield bonds, includes some insider trading, then the concerns about insider trading as in any other securities market apply. It might be optimal for both policymakers and regulators to devote more efforts in monitoring the corporate bond market.

As to the relationships between the option market and the other two markets, ATM put option spreads continue to lead stock returns. The hypothesis that current stock returns have predictive power for future ATM put spread changes can be easily rejected, with an F-value of 0.3838 (Table 9). The hypothesis on the ATM option lead in the stock-option relationship, however, can not be rejected (Table 7). Furthermore, the result concerning the correlation between present bond returns and earlier OTM option spreads is robust even when infrequently traded bonds are considered. Table 8 shows lagged deep OTM options spreads contain valuable information about current bond price changes, with Granger causality test rejecting the null hypothesis that the coefficients for AS_{t-1} through AS_{t-5} are zero at 1% level. However, none of the lagged bond returns are significant in explaining current OTM option spreads, making my conclusion on the option's lead even stronger.

6. Conclusions and Extensions

Taking advantage of a unique corporate bond transaction dataset from NASD, this paper studies whether information-based trading takes place in the high-yield corporate bond market, and how firm-specific information flow across three important securities, stocks, options and corporate bonds, whose value is related to the issuer's underlying assets. In contrast to previous studies [Kwan (1996), Hotchkiss and Ronen (2002)], I find that informed traders do trade in the corporate bond market, and corporate bond returns contain important information about future stock price movements. Both the stock market and the bond market serve important informational roles in the price discovery process. Furthermore, compared to the stock and the bond markets, the option market is a preferred venue for informed trading. It is leading both the stock market and the corporate bond markets in reflecting firm specific information. In addition, there is strong evidence that an informed trader's choice of options with different strike prices depends crucially on what kind of information she has. Unless she is aware of some impending extreme event to a firm, in which case she rushes to buy deep OTM put options on the firm, she will trade ATM options if she obtains milder information.

The analysis of the dynamics of information flow across individual stocks, options and corporate bonds can be extended in several important ways. First, it is interesting to extend this study in both cross-sectional and time-series frameworks. What this study establishes is a world with asymmetric information arrival, with the option market leading the others. It would be interesting to know whether this relationship extends to each individual firm, and if not, how it varies with firm-specific characteristics. Furthermore, how the relative speed of adjustment to new information in different markets changes with contemporaneous market conditions and over time, and whether it differs dramatically between event days and non-event days are of no less interest. Answers to these questions will provide deeper understanding of the price discovery process. An example of work in this direction is Chakravarty, Gulen and Mayhew (2004).

Second, as this study focuses on the lead-lag interrelationships between three closely related securities markets in terms of price, it is equally important to explore the information role of volume. Easley and O'Hara (1992) show that volume contains some information that is not reflected in the price. Blume, Easley and O'Hara (1994) emphasize the role of volume as a statistic for technical analysis. It is interesting to check whether transaction volume in different markets provides additional insights into where informed traders trade and where price discovery takes place. Furthermore, an investigation of the pattern of trading volume in corporate bonds and its time-series variation would contribute to the new area of corporate bond market microstructure.

Third, the identification of informed trading in the high-yield bond market suggests a market microstructure approach to corporate bond pricing. Traditional models of default, including both option-based structural models and reduced form models, have had limited success in explaining the corporate yield spreads observed in actual markets. Even after accounting for liquidity effects, it is still challenging to explain credit spread changes solely based on credit-risk factors [see for example, Collin-Dufresne, Goldstein and Martin (2001), Eom, Helwege and Huang (2003), Duffie and Singleton (2003) and Huang and Huang (2003)]. One inherent assumption under all these models, however, is that the market is complete. If information is asymmetric, then informed traders are better able to adjust their portfolio to incorporate new information, putting uninformed traders at a disadvantage. In equilibrium, investors require higher yield to hold bonds with greater information-based trading. This suggests that in addition to traditional corporate bond pricing factors, risks associated with informed trading are also priced in corporate bonds. The high-yield spreads observed in the market might embed an information premium that is ignored by existing corporate bond pricing models, and correct pricing of information risk in the corporate bond market brings a more ambitious goal into research agenda.

Lastly, as posited by Titman (2002), if the markets for debt, equity and derivatives are not integrated, then the required return premium associated with any risk differs across markets. This directly affects how firms raise capital and hedge. The complete transaction dataset for debt, equity and derivative securities, as well as an accurate pricing model for different risks, allow direct tests of whether the markets for these securities are perfectly integrated, and hence help us to gain a deeper understanding of the Modigliani and Miller (1958) theorem.

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Table 1 **Characteristics of 77 TRACE 50 Bonds and Their Issuing Firms**

Panel A:

Variable	*Mean*	*Median*	*Minimum*	*Maximum*	*Std Dev*
Assets	11471.1	8394	523.8	63545	10195.2
Leverage	0.7819	0.7773	0.3586	1.9119	0.2128
Coupon Rate	7.4812	7.875	1.25	11	2.2228
Time to Maturity	6.369	5.8344	2.0862	26.705	3.3646

Panel B:

Bond Type	SRDEB	SRNT	SRSECNT	SRSUBNT	SRUNNT	SUBDEB	SUBNT	UNNT
Number of Bonds	1	12	2	8	38	1	10	4
Percentage	1.32	15.79	2.63	10.53	50	1.32	13.16	5.26

Panel C:

S&P Rating	BBB	BB	B	CCC	CC	C	NR
Number of Bonds	7	24	29	7	1	1	7
Percentage	9.21	31.58	38.16	9.21	1.32	1.32	9.21

Panel D:

Coupon Type	Variable	Plain Vanilla Fixed Coupon
Number of Bonds	1	76
Percentage	1.3	98.7

Panel E:

Payment Frequency	Semiannually
Number of Bonds	77
Percentage	100

Panel F:

Industry	CG	ENGY	FIN	MANU	SERV	TELE	TRANS
Number of Bonds	1	9	7	30	24	5	1

Percentage	1.3	11.69	9.09	38.96	31.17	6.49	1.3

Panel G:

Callable	Yes	No
Number of Bonds	38	39
Percentage	49.35	50.65

Panel H:

Convertible	Yes	No
Number of Bonds	14	63
Percentage	18.18	81.82

This table contains summary characteristics for the 77 corporate bonds and their issuing firms at the time of their initial entry to the TRACE 50 list. Firm characteristics are based on data from COMPUSTAT, while bond characteristics are determined from the TRACE 50 dataset. Most of these descriptive bond data were obtained from NASD, with the remainder provided by the issuing firms. The following abbreviations are used in this table: for bond type, SRDEB (Senior Debenture), SRNT (Senior Note), SRSECNT (Senior Secured Note), SRSUBNT (Senior Subordinated Note), SRUNNT (Senior Unsecured Note), SUBDEB (Subordinated Debenture), SUBNT (Subordinated Note) and UNNT (Unsecured Note); for industry, CG (Consumer Goods), ENGY (Energy), FIN (Financial), MANU (Manufacturing), SERV (Services), TELE (Telecommunications) and TRANS (Transportation).

Table 2 **Characteristics of 48 Most Frequently Traded TRACE 50 Bonds and Their Issuing Firms**

Panel A:

Variable	***Mean***	***Median***	***Minimum***	***Maximum***	***Std Dev***
Assets	14259.7	10709.7	1613	63545	11564.6
Leverage	0.7963	0.7843	0.4444	1.5206	0.1946
Coupon Rate	7.4121	7.75	1.25	11	2.247
Time to Maturity	6.721	5.8344	2.0862	26.705	4.0662

Panel B:

Bond Type	SRDEB	SRNT	SRSECNT	SRSUBNT	SRUNNT	SUBNT	UNNT
Number of Bonds	1	7	2	4	24	7	3
Percentage	2.08	14.58	4.17	8.33	50.00	14.58	6.25

Panel C:

S&P Rating	BBB	BB	B	CCC	CC	C	NR
Number of Bonds	4	16	17	5	1	0	5
Percentage	8.33	33.33	35.42	10.41	2.08	0.00	10.42

Panel D:

Coupon Type	Variable	Plain Vanilla Fixed Coupon
Number of Bonds	1	47
Percentage	2.08	97.92

Panel E:

Payment Frequency	Semiannually
Number of Bonds	48
Percentage	100.00

Panel F:

Industry	CG	ENGY	FIN	MANU	SERV	TELE	TRANS
Number of Bonds	1	7	4	16	15	5	0

Percentage	2.08	14.58	8.33	33.33	31.25	10.42	0.00

Panel G:

Callable	Yes	No
Number of Bonds	23	25
Percentage	47.92	52.08

Panel H:

Convertible	Yes	No
Number of Bonds	12	36
Percentage	25.00	75.00

This table contains summary characteristics for the 48 most frequently traded TRACE 50 bonds and their issuing firms at the time of their initial entry to the TRACE 50 list. Firm characteristics are based on data from COMPUSTAT, while bond characteristics are determined from the TRACE 50 dataset. Most of these descriptive bond data were obtained from NASD, with the remainder provided by the issuing firms. The following abbreviations are used in this table: for bond type, SRDEB (Senior Debenture), SRNT (Senior Note), SRSECNT (Senior Secured Note), SRSUBNT (Senior Subordinated Note), SRUNNT (Senior Unsecured Note), SUBDEB (Subordinated Debenture), SUBNT (Subordinated Note) and UNNT (Unsecured Note); for industry, CG (Consumer Goods), ENGY (Energy), FIN (Financial), MANU (Manufacturing), SERV (Services), TELE (Telecommunications) and TRANS (Transportation).

Table 3 **Regression of current stock returns on current default-free debt returns, market returns, lagged bond returns, lagged ATM put option spreads, and lagged deep OTM put option spreads for the 48 firms with frequently traded bonds**

Panel A: Estimation Results

	Variable	**Estimated Coefficient**	**t-value**	**Significance Level**
1	Constant	0.0016	2.4145	0.0158
2	DR	-0.1086	-1.2622	0.2069
3	MR	1.3096	32.9130	0.0000
4	SR{1}	0.1823	16.1368	0.0000
5	SR{2}	-0.0094	-0.8059	0.4203
6	SR{3}	-0.0197	-1.6679	0.0954
7	SR{4}	-0.0195	-1.6764	0.0937
8	SR{5}	0.0219	1.9043	0.0569
9	BR{1}	0.0404	2.0034	0.0452
10	BR{2}	0.0851	4.1485	0.0000
11	BR{3}	0.0363	1.7699	0.0768
12	BR{4}	0.0287	1.4297	0.1529
13	BR{5}	0.0037	0.1921	0.8477
14	AS{1}	-0.0027	-2.5129	0.0120
15	AS{2}	0.0004	0.3540	0.7233
16	AS{3}	0.0016	1.2257	0.2204
17	AS{4}	0.0014	1.1121	0.2661
18	AS{5}	-0.0002	-0.1651	0.8689
19	OS{1}	-0.0529	-0.8697	0.3845
20	OS{2}	-0.0027	-0.0382	0.9695
21	OS{3}	0.0206	0.2952	0.7678
22	OS{4}	-0.0223	-0.3199	0.7491
23	OS{5}	0.0241	0.3954	0.6926
24	Adjusted R-Square	0.1639		

Panel B: Granger Causality Tests

Null Hypothesis : The Following Coefficients Are Zero	**F-value**	**Significance Level**
BR: Lag 1 to Lag 5	3.9121	0.0015
AS: Lag 1 to Lag 5	2.3846	0.0360
OS: Lag 1 to Lag 5	1.0243	0.4013

Panel A presents the results from estimating the following model:

$$SR_{i,t} = \alpha_1 + \gamma_{11} MR_t + \gamma_{12} DR_{i,t} + \sum_{j=1}^{5} \beta_{11,-j} SR_{i,t-j} + \sum_{j=1}^{5} \beta_{12,-j} BR_{i,t-j} + \sum_{j=1}^{5} \beta_{13,-j} AS_{i,t-j} + \sum_{j=1}^{5} \beta_{14,-j} OS_{i,t-j} + \varepsilon_{i1,t}$$

SR and BR represent daily stock return and bond return, calculated from end-of-day closing prices. MR is the S&P 500 index return, and DR denotes return on a default-free debt with future cash flows matched perfectly with the high-yield corporate bond. AS and OS stand for ATM put options spreads and OTM put options spreads respectively. They are normalized by dividing the bid-ask spreads by the average of bid and ask quotes.

Panel B contains the results from Granger Causality tests on whether all β_{12}, β_{13}, and β_{14} are equal to zero.

Table 4 **Regression of current bond returns on current default-free debt returns, market returns, lagged bond returns, lagged ATM put option spreads, and lagged deep OTM put option spreads for the 48 firms with frequently traded bonds**

Panel A: Estimation Results

	Variable	**Estimated Coefficient**	**t-value**	**Significance Level**
1	Constant	0.0015	3.4504	0.0006
2	DR	0.0482	0.9116	0.3620
3	MR	0.1081	4.4336	0.0000
4	SR{1}	0.1410	20.3446	0.0000
5	SR{2}	0.0887	12.4303	0.0000
6	SR{3}	0.0473	6.5836	0.0000
7	SR{4}	0.0264	3.7171	0.0002
8	SR{5}	0.0182	2.5803	0.0099
9	BR{1}	-0.3014	-24.3606	0.0000
10	BR{2}	-0.1520	-11.8846	0.0000
11	BR{3}	-0.0899	-7.0288	0.0000
12	BR{4}	-0.0680	-5.4416	0.0000
13	BR{5}	-0.0632	-5.4159	0.0000
14	AS{1}	-0.0006	-0.9793	0.3275
15	AS{2}	0.0006	0.7520	0.4521
16	AS{3}	-0.0001	-0.0875	0.9303
17	AS{4}	-0.0002	-0.3191	0.7497
18	AS{5}	0.0007	1.1255	0.2604
19	OS{1}	-0.0382	-1.0249	0.3054
20	OS{2}	-0.0328	-0.7880	0.4307
21	OS{3}	0.0349	0.8386	0.4017
22	OS{4}	0.0367	0.8842	0.3766
23	OS{5}	-0.0265	-0.7091	0.4783
24	Adjusted R-Square	0.1521		

Panel B: Granger Causality Tests

Null Hypothesis : The Following Coefficients Are Zero	**F-value**	**Significance Level**
SR: Lag 1 to Lag 5	132.7280	0.0000
AS: Lag 1 to Lag 5	0.5171	0.7635
OS: Lag 1 to Lag 5	2.5503	0.0259

Panel A presents the results from estimating the following model:

$$BR_{i,t} = \alpha_2 + \gamma_{21} MR_t + \gamma_{22} DR_{i,t} + \sum_{j=1}^{5} \beta_{21,-j} SR_{i,t-j} + \sum_{j=1}^{5} \beta_{22,-j} BR_{i,t-j} + \sum_{j=1}^{5} \beta_{23,-j} AS_{i,t-j} + \sum_{j=1}^{5} \beta_{24,-j} OS_{i,t-j} + \varepsilon_{i2,t}$$

SR and BR represent daily stock return and bond return, calculated from end-of-day closing prices. MR is the S&P 500 index return, and DR denotes return on a default-free debt with future cash flows matched perfectly with the high-yield corporate bond. AS and OS stand for ATM put options spreads and OTM put options spreads respectively. They are normalized by dividing the bid-ask spreads by the average of bid and ask quotes.

Panel B contains the results from Granger Causality tests on whether all β_{21}, β_{23}, and β_{24} are equal to zero.

Table 5 **Regression of current ATM put option spreads on current default-free debt returns, market returns, lagged bond returns, lagged ATM put option spreads, and lagged deep OTM put option spreads for the 48 firms with frequently traded bonds**

Panel A: Estimation Results

	Variable	**Estimated Coefficient**	**t-value**	**Significance Level**
1	Constant	0.0570	9.6733	0.0000
2	DR	-0.4610	-0.4979	0.6186
3	MR	1.2476	2.8417	0.0045
4	SR{1}	-0.1172	-0.8746	0.3818
5	SR{2}	-0.0381	-0.2496	0.8029
6	SR{3}	0.0246	0.1583	0.8742
7	SR{4}	-0.1119	-0.7449	0.4563
8	SR{5}	0.0057	0.0420	0.9665
9	BR{1}	0.1325	0.5591	0.5761
10	BR{2}	0.3471	1.4638	0.1433
11	BR{3}	0.0462	0.1902	0.8491
12	BR{4}	0.5185	2.2185	0.0266
13	BR{5}	-0.0036	-0.0161	0.9872
14	AS{1}	1.0232	82.4139	0.0000
15	AS{2}	-0.3624	-20.4031	0.0000
16	AS{3}	0.2108	11.5775	0.0000
17	AS{4}	-0.0872	-4.8705	0.0000
18	AS{5}	0.0557	4.4403	0.0000
19	OS{1}	-0.3159	-0.4433	0.6576
20	OS{2}	0.2105	0.2154	0.8295
21	OS{3}	0.6640	0.6836	0.4943
22	OS{4}	-0.9196	-0.9414	0.3465
23	OS{5}	1.1852	1.6523	0.0985
24	Adjusted R-Square	0.4830		

Panel B: Granger Causality Tests

Null Hypothesis : The Following Coefficients Are Zero	**F-value**	**Significance Level**
SR: Lag 1 to Lag 5	0.3682	0.8706
BR: Lag 1 to Lag 5	1.3770	0.2295
OS: Lag 1 to Lag 5	7.0489	0.0000

Panel A presents the results from estimating the following model:

$$AS_{i,t} = \alpha_3 + \gamma_{31} MR_t + \gamma_{32} DR_{i,t} + \sum_{j=1}^{5} \beta_{31,-j} SR_{i,t-j} + \sum_{j=1}^{5} \beta_{32,-j} BR_{i,t-j} + \sum_{j=1}^{5} \beta_{33,-j} AS_{i,t-j} + \sum_{j=1}^{5} \beta_{34,-j} OS_{i,t-j} + \varepsilon_{i3,t}$$

SR and BR represent daily stock return and bond return, calculated from end-of-day closing prices. MR is the S&P 500 index return, and DR denotes return on a default-free debt with future cash flows matched perfectly with the high-yield corporate bond. AS and OS stand for ATM put options spreads and OTM put options spreads respectively. They are normalized by dividing the bid-ask spreads by the average of bid and ask quotes.

Panel B contains the results from Granger Causality tests on whether all β_{31}, β_{32}, and β_{34} are equal to zero.

Table 6 **Regression of current OTM put option spreads on current default-free debt returns, market returns, lagged bond returns, lagged ATM put option spreads, and lagged deep OTM put option spreads for the 48 firms with frequently traded bonds**

Panel A: Estimation Results

	Variable	**Estimated Coefficient**	**t-value**	**Significance Level**
1	Constant	0.0002	2.0223	0.0432
2	DR	-0.0102	-0.6509	0.5151
3	MR	0.0169	2.2759	0.0229
4	SR{1}	0.0027	1.1792	0.2384
5	SR{2}	0.0027	1.0148	0.3102
6	SR{3}	0.0009	0.3306	0.7410
7	SR{4}	0.0015	0.5689	0.5694
8	SR{5}	0.0021	0.8884	0.3744
9	BR{1}	0.0008	0.2023	0.8397
10	BR{2}	-0.0013	-0.3050	0.7603
11	BR{3}	-0.0016	-0.3749	0.7078
12	BR{4}	-0.0010	-0.2455	0.8061
13	BR{5}	-0.0044	-1.1453	0.2521
14	AS{1}	0.0001	0.2999	0.7643
15	AS{2}	-0.0002	-0.6350	0.5255
16	AS{3}	0.0002	0.7181	0.4728
17	AS{4}	0.0001	0.2940	0.7688
18	AS{5}	0.0000	0.1593	0.8735
19	OS{1}	0.9952	81.1621	0.0000
20	OS{2}	-0.3339	-19.3703	0.0000
21	OS{3}	0.3232	18.7878	0.0000
22	OS{4}	-0.1152	-6.6814	0.0000
23	OS{5}	0.1199	9.7091	0.0000
24	Adjusted R-Square	0.9231		

Panel B: Granger Causality Tests

Null Hypothesis : The Following Coefficients Are Zero	**F-value**	**Significance Level**
BR: Lag 1 to Lag 5	1.6781	0.1361
AS: Lag 1 to Lag 5	0.3417	0.8878
OS: Lag 1 to Lag 5	0.8776	0.4951

Panel A presents the results from estimating the following model:

$$OS_{i,t} = \alpha_4 + \gamma_{41} MR_t + \gamma_{42} DR_{i,t} + \sum_{j=1}^{5} \beta_{41,-j} SR_{i,t-j} + \sum_{j=1}^{5} \beta_{42,-j} BR_{i,t-j} + \sum_{j=1}^{5} \beta_{43,-j} AS_{i,t-j} + \sum_{j=1}^{5} \beta_{44,-j} OS_{i,t-j} + \varepsilon_{i4,t}$$

SR and BR represent daily stock return and bond return, calculated from end-of-day closing prices. MR is the S&P 500 index return, and DR denotes return on a default-free debt with future cash flows matched perfectly with the high-yield corporate bond. AS and OS stand for ATM put options spreads and OTM put options spreads respectively. They are normalized by dividing the bid-ask spreads by the average of bid and ask quotes.

Panel B contains the results from Granger Causality tests on whether all β_{41}, β_{42}, and β_{43} are equal to zero.

Table 7 **Regression of current stock returns on current default-free debt returns, market returns, lagged bond returns, lagged ATM put option spreads, and lagged deep OTM put option spreads for the 77 firms with frequently traded bonds**

Panel A: Estimation Results

	Variable	Estimated Coefficient	t-value	Significance Level
1	Constant	0.0002	2.4229	0.0154
2	DR	-0.0063	-1.1805	0.2379
3	MR	0.0173	32.7755	0.0000
4	SR{1}	0.0027	16.2631	0.0000
5	SR{2}	0.0026	-0.8512	0.3947
6	SR{3}	0.0011	-1.6758	0.0938
7	SR{4}	0.0012	-1.6556	0.0978
8	SR{5}	0.0022	1.8647	0.0623
9	BR{1}	0.0010	1.9932	0.0463
10	BR{2}	-0.0015	4.1436	0.0000
11	BR{3}	-0.0012	1.7636	0.0779
12	BR{4}	-0.0011	1.4180	0.1563
13	BR{5}	-0.0043	0.2297	0.8183
14	AS{1}	0.0001	-2.5685	0.0102
15	AS{2}	-0.0002	0.3814	0.7029
16	AS{3}	0.0002	1.2717	0.2035
17	AS{4}	0.0001	1.1099	0.2671
18	AS{5}	0.0001	-0.2296	0.8184
19	OS{1}	1.0105	-0.8147	0.4153
20	OS{2}	-0.3567	-0.0297	0.9763
21	OS{3}	0.3430	0.3230	0.7467
22	OS{4}	-0.1318	-0.3703	0.7112
23	OS{5}	0.1241	0.3702	0.7112
24	Adjusted R-Square	0.1635		

Panel B: Granger Causality Tests

Null Hypothesis : The Following Coefficients Are Zero	**F-value**	**Significance Level**
BR: Lag 1 to Lag 5	3.8959	0.0016
AS: Lag 1 to Lag 5	2.4465	0.0318
OS: Lag 1 to Lag 5	0.9664	0.4368

Panel A presents the results from estimating the following model:

$$SR_{i,t} = \alpha_1 + \gamma_{11} MR_t + \gamma_{12} DR_{i,t} + \sum_{j=1}^{5} \beta_{11,-j} SR_{i,t-j} + \sum_{j=1}^{5} \beta_{12,-j} BR_{i,t-j} + \sum_{j=1}^{5} \beta_{13,-j} AS_{i,t-j} + \sum_{j=1}^{5} \beta_{14,-j} OS_{i,t-j} + \varepsilon_{i1,t}$$

SR and BR represent daily stock return and bond return, calculated from end-of-day closing prices. MR is the S&P 500 index return, and DR denotes return on a default-free debt with future cash flows matched perfectly with the high-yield corporate bond. AS and OS stand for ATM put options spreads and OTM put options spreads respectively. They are normalized by dividing the bid-ask spreads by the average of bid and ask quotes.

Panel B contains the results from Granger Causality tests on whether all β_{12}, β_{13}, and β_{14} are equal to zero.

Table 8 **Regression of current bond returns on current default-free debt returns, market returns, lagged bond returns, lagged ATM put option spreads, and lagged deep OTM put option spreads for the 77 firms with frequently traded bonds**

Panel A: Estimation Results

	Variable	**Estimated Coefficient**	**t-value**	**Significance Level**
1	Constant	0.0015	3.4360	0.0006
2	DR	0.0526	0.9864	0.3240
3	MR	0.1080	4.4177	0.0000
4	SR{1}	0.1411	20.3171	0.0000
5	SR{2}	0.0892	12.4718	0.0000
6	SR{3}	0.0478	6.6383	0.0000
7	SR{4}	0.0266	3.7420	0.0002
8	SR{5}	0.0182	2.5735	0.0101
9	BR{1}	-0.3066	-24.7193	0.0000
10	BR{2}	-0.1533	-11.9384	0.0000
11	BR{3}	-0.0904	-7.0384	0.0000
12	BR{4}	-0.0684	-5.4452	0.0000
13	BR{5}	-0.0634	-5.4190	0.0000
14	AS{1}	-0.0006	-0.9544	0.3399
15	AS{2}	0.0006	0.7225	0.4700
16	AS{3}	-0.0001	-0.0923	0.9265
17	AS{4}	-0.0002	-0.3188	0.7499
18	AS{5}	0.0007	1.1363	0.2559
19	OS{1}	-0.0370	-0.9886	0.3229
20	OS{2}	-0.0328	-0.7870	0.4313
21	OS{3}	0.0339	0.8120	0.4168
22	OS{4}	0.0369	0.8881	0.3745
23	OS{5}	-0.0270	-0.7188	0.4723
24	Adjusted R-Square	0.1520		

Panel B: Granger Causality Tests

Null Hypothesis : The Following Coefficients Are Zero	**F-value**	**Significance Level**
SR: Lag 1 to Lag 5	132.1312	0.0000
AS: Lag 1 to Lag 5	0.5083	0.7702
OS: Lag 1 to Lag 5	2.2486	0.0468

Panel A presents the results from estimating the following model:

$$BR_{i,t} = \alpha_2 + \gamma_{21} MR_t + \gamma_{22} DR_{i,t} + \sum_{j=1}^{5} \beta_{21,-j} SR_{i,t-j} + \sum_{j=1}^{5} \beta_{22,-j} BR_{i,t-j} + \sum_{j=1}^{5} \beta_{23,-j} AS_{i,t-j} + \sum_{j=1}^{5} \beta_{24,-j} OS_{i,t-j} + \varepsilon_{i2,t}$$

SR and BR represent daily stock return and bond return, calculated from end-of-day closing prices. MR is the S&P 500 index return, and DR denotes return on a default-free debt with future cash flows matched perfectly with the high-yield corporate bond. AS and OS stand for ATM put options spreads and OTM put options spreads respectively. They are normalized by dividing the bid-ask spreads by the average of bid and ask quotes.

Panel B contains the results from Granger Causality tests on whether all β_{21}, β_{23}, and β_{24} are equal to zero.

Table 9 **Regression of current ATM put option spreads on current default-free debt returns, market returns, lagged bond returns, lagged ATM put option spreads, and lagged deep OTM put option spreads for the 77 firms with frequently traded bonds**

Panel A: Estimation Results

	Variable	**Estimated Coefficient**	**t-value**	**Significance Level**
1	Constant	0.0569	9.6685	0.0000
2	DR	-0.3933	-0.4239	0.6717
3	MR	1.2400	2.8338	0.0046
4	SR{1}	-0.1203	-0.9023	0.3669
5	SR{2}	-0.0313	-0.2067	0.8362
6	SR{3}	0.0283	0.1827	0.8551
7	SR{4}	-0.1169	-0.7831	0.4336
8	SR{5}	0.0013	0.0098	0.9922
9	BR{1}	0.1094	0.4638	0.6428
10	BR{2}	0.3585	1.5203	0.1285
11	BR{3}	0.0393	0.1631	0.8705
12	BR{4}	0.5490	2.3615	0.0182
13	BR{5}	-0.0169	-0.0759	0.9395
14	AS{1}	1.0248	82.2767	0.0000
15	AS{2}	-0.3623	-20.3270	0.0000
16	AS{3}	0.2106	11.5677	0.0000
17	AS{4}	-0.0867	-4.8554	0.0000
18	AS{5}	0.0540	4.3073	0.0000
19	OS{1}	-0.3204	-0.4508	0.6522
20	OS{2}	0.2860	0.2938	0.7689
21	OS{3}	0.6454	0.6672	0.5047
22	OS{4}	-0.7887	-0.8109	0.4175
23	OS{5}	0.9964	1.3938	0.1634
24	Adjusted R-Square	0.4870		

Panel B: Granger Causality Tests

Null Hypothesis : The Following Coefficients Are Zero	**F-value**	**Significance Level**
SR: Lag 1 to Lag 5	0.3838	0.8602
BR: Lag 1 to Lag 5	1.4924	0.1887
OS: Lag 1 to Lag 5	6.8842	0.0000

Panel A presents the results from estimating the following model:

$$AS_{i,t} = \alpha_3 + \gamma_{31} MR_t + \gamma_{32} DR_{i,t} + \sum_{j=1}^{5} \beta_{31,-j} SR_{i,t-j} + \sum_{j=1}^{5} \beta_{32,-j} BR_{i,t-j} + \sum_{j=1}^{5} \beta_{33,-j} AS_{i,t-j} + \sum_{j=1}^{5} \beta_{34,-j} OS_{i,t-j} + \varepsilon_{i3,t}$$

SR and BR represent daily stock return and bond return, calculated from end-of-day closing prices. MR is the S&P 500 index return, and DR denotes return on a default-free debt with future cash flows matched perfectly with the high-yield corporate bond. AS and OS stand for ATM put options spreads and OTM put options spreads respectively. They are normalized by dividing the bid-ask spreads by the average of bid and ask quotes.

Panel B contains the results from Granger Causality tests on whether all β_{31}, β_{32}, and β_{34} are equal to zero.

Table 10 **Regression of current OTM put option spreads on current default-free debt returns, market returns, lagged bond returns, lagged ATM put option spreads, and lagged deep OTM put option spreads for the 77 firms with frequently traded bonds**

Panel A: Estimation Results

	Variable	**Estimated Coefficient**	**t-value**	**Significance Level**
1	Constant	0.0002	2.0052	0.0450
2	DR	-0.0063	-0.4008	0.6886
3	MR	0.0173	2.3276	0.0200
4	SR{1}	0.0027	1.1858	0.2357
5	SR{2}	0.0026	0.9656	0.3343
6	SR{3}	0.0011	0.3900	0.6965
7	SR{4}	0.0012	0.4531	0.6505
8	SR{5}	0.0022	0.9273	0.3538
9	BR{1}	0.0010	0.2433	0.8078
10	BR{2}	-0.0015	-0.3609	0.7182
11	BR{3}	-0.0012	-0.2816	0.7783
12	BR{4}	-0.0011	-0.2635	0.7921
13	BR{5}	-0.0043	-1.1234	0.2613
14	AS{1}	0.0001	0.2492	0.8032
15	AS{2}	-0.0002	-0.5366	0.5916
16	AS{3}	0.0002	0.7155	0.4743
17	AS{4}	0.0001	0.1883	0.8507
18	AS{5}	0.0001	0.2418	0.8089
19	OS{1}	1.0105	82.1563	0.0000
20	OS{2}	-0.3567	-20.4802	0.0000
21	OS{3}	0.3430	19.7159	0.0000
22	OS{4}	-0.1318	-7.5642	0.0000
23	OS{5}	0.1241	10.0197	0.0000
24	Adjusted R-Square	0.9230		

Panel B: Granger Causality Tests

Null Hypothesis : The Following Coefficients Are Zero	**F-value**	**Significance Level**
SR: Lag 1 to Lag 5	1.4603	0.1993
BR: Lag 1 to Lag 5	0.3573	0.8778
AS: Lag 1 to Lag 5	0.8832	0.4913

Panel A presents the results from estimating the following model:

$$OS_{i,t} = \alpha_4 + \gamma_{41} MR_t + \gamma_{42} DR_{i,t} + \sum_{j=1}^{5} \beta_{41,-j} SR_{i,t-j} + \sum_{j=1}^{5} \beta_{42,-j} BR_{i,t-j} + \sum_{j=1}^{5} \beta_{43,-j} AS_{i,t-j} + \sum_{j=1}^{5} \beta_{44,-j} OS_{i,t-j} + \varepsilon_{i4,t}$$

SR and BR represent daily stock return and bond return, calculated from end-of-day closing prices. MR is the S&P 500 index return, and DR denotes return on a default-free debt with future cash flows matched perfectly with the high-yield corporate bond. AS and OS stand for ATM put options spreads and OTM put options spreads respectively. They are normalized by dividing the bid-ask spreads by the average of bid and ask quotes.

Panel B contains the results from Granger Causality tests on whether all β_{41}, β_{42}, and β_{43} are equal to zero.