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Three Essays in Finance

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Dedication

To my parents and my husband, for their unconditional love and constant encouragements, and my dear friends, who walked with me along the way.

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Abstract

This dissertation is composed of three essays on corporate credit markets and corporate finance. The first essay examines the impact of unconventional monetary policies (UMPs), including Quantitative Easing (QE), Operation Twist (OT), and Forward Guidance (FG), on corporate credit markets. These policies were expected to reduce credit spreads by decreasing credit risk premium and/or liquidity premium, and to further lengthen borrowing maturity. During the crisis, Quantitative Easing (QE) 1 reduced these risk premia as expected. However, after the crisis, QE 2 and Operation Twist announcements increased fears of a weaker economy and, consequently, widened credit spreads. In contrast, Forward Guidance reduced credit risk premia without increasing fear premia. I also find that QE had a minimal effect on corporate bond maturities, which most likely reflected the considerable increase of new Treasury issuance and the declining fraction of preferred-habitat investors. The largest impact on corporate bond maturities came from UMPs that significantly flattened the yield curve.

The second essay (published in the *Journal of Fixed Income*) studies the impact of margin requirements on the Credit Default Swap (CDS) basis. The CDS basis was significantly negative during the 2007-2009 financial crisis, which was considered an anomaly. Using single-name CDS data, we find that the CDS basis decreases as the funding costs, credit risk premium, and market illiquidity increase. Further, cross-sectional results show that the sensitivities of the CDS basis to funding costs, credit risk premium, and market illiquidity are priced, even after controlling for the individual bond liquidity and other firm characteristics. The results are consistent with

the margin-based asset pricing theories that the difference in margin requirements on two otherwise identical securities gives rise to bases.

The third essay (co-authored with Yongqiang Chu) examines the relationship between a firm's leverage and that of its customers. The bargaining theory of capital structure predicts that, when a customer increases its bargaining power by increasing its leverage, the supplier will raise its leverage as well in order to maintain its bargaining power. However, the relation-specific investment theory of capital structure suggests an opposite relationship. An increased leverage ratio reduces the value of such investments, and, therefore, the supplier may not compete on the leverage ratio. We find that, in general, a firm's leverage is positively associated with its customer's leverage, and we find empirical evidence supporting both theories. The result is robust to a battery of specifications and instrumental variables.

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Chapter 1

The Impact of Unconventional Monetary Policies:Evidence from Corporate Credit Markets

1.1 Introduction

When the Federal Funds (FF) rate reached zero in late 2008, the Federal Reserve (Fed) undertook unconventional monetary policies (UMPs), which include Quantitative Easing (QE), Operation Twist (OT), and Forward Guidance (FG), to lower long-term interest rates.[1] The goal of UMPs was to ease credit market conditions and, consequently, to increase real investments. Although UMPs decreased Treasury rates as expected, they did not impact credit market conditions according to the plan.[2] For example, when studying Credit Default Swap (CDS) spreads, which directly measure corporate borrowing costs, Krishnamurthy and Vissing-Jorgensen [2011] document that CDS spreads decreased for some firms in QE 1 but increased, on average, in

[1] QE programs are also known as Large-scale Asset Purchase programs, which are used to purchase long-term agency, agency mortgage-backed, and Treasury securities. OT is used to buy long-term Treasury securities, which is financed by selling the same amount of short-term Treasury securities. FG in this paper refers the time-contingent FG announcements, in which the Fed stated that they would keep the FF rate at zero for an extended period.

[2] In general, the literature suggests that these programs effectively decrease long-term Treasury rates. For example, Gagnon et al. [2010], Krishnamurthy and Vissing-Jorgensen [2012], D'Amico and King [2013], Joyce et al. [2012], Greenwood and Vayanos [2010], and Wright [2012] find that QE programs decreased interest rates; Swanson et al. [2011] find that the 1960 OT decreased interest rates; and Woodford [2012] find that time-contingent FG decreased interest rates.

QE 2.[3] These empirical findings are difficult to explain if UMPs worked as the Fed intended.

Using single-name CDS data and corporate bond issuance data, this paper investigates the channels through which UMPs affected corporate credit markets. Previous literature suggests that UMPs could decrease credit spreads by decreasing credit risk premia and/or liquidity risk premia (e.g., Gilchrist and Zakrajšek 2013; Gagnon et al. 2010; Hancock and Passmore 2011; He and Xiong 2012). However, UMPs could also increase credit spreads if their main impact was to stoke fears of another downturn. When investors adjust their expectations of the economy after monetary policy actions, UMPs could deliver the message that the Fed forecasts a weaker economy (Romer and Romer 2000; den Haan 2013). In such cases, UMPs might increase credit spreads by creating a "fear" premium. This paper examines each UMP and its impact on credit risk premia, liquidity premia, and "fear" premia.

This paper also relates the changes in CDS spreads during UMP announcements to firm fundamentals to examine the cross-sectional impact of these programs. Studies such as Almeida et al. [2009] and Gopalan et al. [2010] indicate thatïijŇ among non-financial firms, those with a large amount of maturing debt are more likely the firms in critical conditions in a frozen credit market. Therefore, UMPs should have helped firms with high rollover risks. However, the QE literature such as D'Amico and King [2013], Greenwood and Vayanos [2010], and Hancock and Passmore [2011] suggests that QEs increase the demand for assets that are close substitutes for assets purchased by the Fed, which implies that QE would have had a greater impact on high-quality firms. Alternatively, by pushing risk-free rates to extraordinarily low levels, the Fed intended to drive investors into riskier assets (e.g., Rajan 2013). Such

[3]CDS spreads are the market prices of corporate credit risk and are gradually adopted in determining corporate debt prices. For example, since the second quarter of 2008, one third to a half of total investment-grade bank lending in the syndicated loan market ties loan interest rates to CDS spreads (Ivanov et al. 2014).

"reaching-for-yield" would have decreased CDS spreads more for riskier firms.

Finally, this paper analyzes corporate bond issuance maturities to better understand the channels through which UMPs affect corporate financing decisions. The Fed's rationale for reducing long-term interest rates, as opposed to short-term interest rates, is to increase corporate debt issuance related to corporate investments (Rajan 2013). This goal could be achieved through the gap-filling channel (Greenwood et al. 2010), which relies on the preferred-habitat theory. This theory argues that, a lower supply of long-term Treasuries will spur firms to issue long-term debt. An alternative channel is market-timing, which argues that firms time the market by issuing debt at the maturities that have the lowest interest rates (e.g., Stein 1996; Baker et al. 2003). Therefore, by flattening the yield curve, UMPs could have induced firms to issue longer-term debt.

Using an event-style two-step panel regression methodology, I find that the 12 announcements related to expanding UMPs had inconsistent effects on CDS spreads. QE 1 announcements reduced all three risk premia. However, QE 2 and OT announcements increased the "fear" premia by about 10%, which accounted for more than 1/3 of the total increases in average CDS spreads. These later announcements, especially those indicating the need for stimulus but not giving the specific plans, had the most negative effects. In contrast, FG, which eliminated the medium-term uncertainties in FF rates, had desirable outcomes and reduced credit risk premia and "fear" premia. Further analyses show that these findings are unlikely to be driven by non-UMP events.

My results show that the impact of UMPs was most significant to large firms, which cannot be explained by the liquidity of CDS contracts. I also find evidence consistent with flight-to-quality and reaching-for-yield. When QE 2 and OT announcements increased "fear" premia, firms with better quality (higher distance-to-default) experienced smaller increases in CDS spreads, supporting a flight-to-quality.

And when FG reduced the "fear" premia, firms with higher leverage ratios experienced greater declines in CDS spreads, suggesting a reaching-for-yield. In addition, I find that only the fifth QE 1 announcement that specified the amount of Treasury purchase reduced corporate rollover risk, supporting the "substitution" argument in the QE literature.

Using corporate bond issuance data between 1990 and 2012, I find that firms did not typically extend borrowing maturity during QE 1 and 2 periods, whereas, in the FG/OT period, highly rated firms did. QE 1 and 2 had little effect on corporate bond maturity because they did not significantly reduce the average Treasury maturity, which left little room for the gap-filling channel. Further, the fraction of preferred-habitat investors required for gap-filling to work (approximately 30%) was higher than the level that existed after 2008 (approximately 20%).[4] In contrast, market-timing is an important factor in explaining the changes in corporate bond maturities in FG/OT periods. Both term spreads and the interest rate levels were lowered as a result of the FG in August 2011 and were pushed even lower by the OT that started in September 2011. Because the term spreads of highly rated corporate bonds closely trace those of Treasuries, such firms could take advantage of low term spreads and time the market by extending their bond maturities. My results indicate that the decreases in term spreads contributed 1 year out of the 1.2 years increase in investment-grade (IG) corporate bond maturities during the FG/OT period.

The Fed uses UMPs to stimulate the economy at the zero lower bound. Of the three programs, I find that, although QE had a positive impact in a crisis, FG came closest to accomplishing what the Fed intended in a recovery period. FG both eliminated the uncertainties about interest rate policies in the medium term and flattened the yield curve. Hence, it reduced risk premia and encouraged firms to issue long-

[4] Greenwood and Vayanos [2010] and Chen et al. [2012b] indicate that preferred-habitat investors could be defined as insurance companies, pension, and retirement funds.

term debt. FG avoided the dilemma that a new monetary stimulus in the recovery period might actually increase the fear of another downturn.

The evidence from corporate markets in this paper helps to explain several findings and concerns in the literature. First, Krishnamurthy and Vissing-Jorgensen [2012] find that CDS spreads increased on QE 2 announcements; additionally, Gilchrist et al. [2014] find that the credit spreads of BBB-rated corporate bonds widened in response to UMPs. My results suggest that a stimulus program in the recovery period could spur fears of another downturn, which in turn would increase CDS spreads. Second, Bernanke and Reinhart [2004] discuss these possible programs and raise the concern that, if FG were to lack credibility, it could be ineffective. My paper examines these policies in a unified framework and shows that the time-contingent FG was most effective in extending investors' expectations of low interest rates and had the most desirable results for non-financial firms. Third, Swanson et al. [2011] show that the 1960 OT had a small effect on high-quality bond yields and little effect on relatively lower-quality bond yields. My findings show that the impact of UMPs is more prominent on larger firms, which are more sensitive to macroeconomic conditions.

The rest of the paper proceeds as follows. Section 2 discusses the related literature and hypotheses. Section 3 describes the methodology and empirical framework. Section 4 presents a description of data and summary statistics. Section 5 shows the empirical results on how each UMP affected credit spreads. Section 6 displays the empirical results on the cross-sectional heterogeneous effects of UMPs. Section 7 shows the empirical results on how UMPs changed corporate bond maturities. Section 8 presents the conclusions.

1.2 Literature Review and Hypothesis Development

The Fed exhausted its ability to use the FF rate in late 2008. Since then, the Fed has continued a series of UMPs to lower long-term interest rates, increase investments, and reduce the unemployment rate (e.g., Bernanke 2009). The first QE announcement was made on November 25, 2008, which only involved purchasing agency bonds and agency mortgage-backed securities (MBS). Later, the Fed expanded the program to include purchasing medium- to long-term Treasury bonds. The first round of QE purchased \$850 billion in agency MBS, \$175 billion in agency debt, and \$300 billion in Treasuries. QE 2 was initiated on August 10, 2010 by an FOMC statement, which said that the Fed would continue purchasing assets but without a specified amount. The Fed announced a \$600 billion purchase of Treasuries on November 3, 2010. On August 9, 2011, the Fed took on the time-contingent FG and announced that they would keep the FF rate at zero until mid-2013. An FOMC statement on January 25, 2012 extended this period to late 2014. Furthermore, the Fed took on the OT to sell off \$400 billion in short-term Treasuries and buy \$400 billion in long-term Treasuries on September 21, 2011. An FOMC statement on June 20, 2012 extended the amount to \$600 billion.

The literature shows that QE programs reduced Treasury rates mainly through the preferred-habitat/ portfolio-balance channel. The preferred-habitat theory (Culbertson 1957) assumes that preferred-habitat investors favor long-term safe securities to match their liability maturity and risk structures (Chen et al. 2012b). When the supply of long-term government securities is less than the amount desired by preferred-habitat investors, the interest rates on long-term government securities will be lower than the rates implied by the expectations theory. Researchers such as Greenwood and Vayanos [2010], Gagnon et al. [2010], Krishnamurthy and Vissing-Jorgensen [2011], and D'Amico and King [2013] provide supportive empirical evidence of this theory. Swanson et al. [2011] argue that OT should have similar effects as QE

2 because they are similar in size and assets. They further show that the 1960 OT decreased interest rates. Woodford [2012] shows that the time-contingent FG decreased long-term interest rates. Swanson and Williams [2012] show that FG increased the expected time until the FF rate increased from 25 bps and, therefore, enhanced the impact of zero FF rates on medium- to long-term interest rates. Hanson and Stein [2012] argue that depressing short-term interest rates could reduce long-term real interest rates because risk-tolerant investors tend to reach for yield.

UMPs could have reduced credit spreads by reducing credit risk premia. Lower Treasury rates could have led to lower corporate debt yields given unchanged credit spreads (Gilchrist and Zakrajšek 2013; Chen et al. 2013). Lower yields could have resulted in lower financing costs and better investment opportunities, which would have led to decreased credit risk and credit risk premia. QE and OT could also have reduced credit spreads by reducing liquidity risk premia. In economic downturns, investors worry that they may have to liquidate securities at a fire-sale price, and, therefore, they require higher spreads on the assets that are more illiquid (e.g.,He and Xiong 2012). Because the Fed was committed as a significant buyer, it assured investors that they could sell easily when needed, which would have reduced liquidity induced credit risk premia (Gagnon et al. 2010). Therefore, the first two parts of the first hypothesis are as follows:

Hypothesis 1 (a): UMPs decreased credit spreads by reducing credit risk premia.

Hypothesis 1 (b): QE and OT decreased credit spreads by reducing liquidity risk premia.

In contrast, UMPs could also increase credit spreads. Investors may take monetary policy actions as signals of the Fed's private information and adjust their expectations accordingly (Romer and Romer 2000). Almost all UMP announcements began with the statement that the economy was weak and needed stimulus. If investors believed that the Fed had more information, they would adjust their economic outlook expectations (den Haan 2013). In this case, the "fear" of bad realizations would create a "fear" premia. FG could be an exception because FG reduced the uncertainty about the path of interest rates. Therefore, part three of the first hypothesis is as follows:

Hypothesis 1 (c): UMPs could increase credit spreads by increasing the "fear" premia, but FG could have the opposite effect.

These effects could differ over time. The UMPs implemented in a crisis could have more favorable influences because these announcements calmed the panic by showing that the Fed still had the power to ease market conditions (e.g., Swanson et al. 2011; den Haan 2013). They could also be more helpful after the crisis. By purchasing safe assets and decreasing risk-free rates, the Fed was hoping that investors would reach for yield and reinvest in riskier assets, which in turn could improve broad credit markets such as corporate credit markets (e.g., Rajan 2013). However, in crises, investors prefer safer assets and are reluctant to invest in riskier assets (e.g., Erel et al. 2012; Bai et al. 2012). Put differently, crises involve flight-to-quality rather than reaching-for-yield. Therefore, UMPs could be more helpful for corporate credit markets in the recovery period through the reaching-for-yield channel. Part four of the first hypothesis is as follows:

Hypothesis 1 (d): UMPs could have been more useful for corporate credit markets during the crisis when the risk-aversion was high; they could also have been more helpful after the crisis because of reaching-for-yield.

Next, the literature that studies the average changes in credit spreads by rating categories suggests that the effects of UMPs were cross-sectionally heterogeneous on firms. Krishnamurthy and Vissing-Jorgensen [2011] document that CDS spreads decreased on QE 1 only for very high- and low-rated firms and increased on QE 2 for all firms. Swanson et al. [2011] show that the 1960 OT had a small effect on very high-quality firms and little effect on lower-quality bond indices, and they ascribe the difference to the asset substitution channel.

These heterogeneous effects could be attributed to both the credit market conditions when the UMPs were implemented and the approaches of these policies. Unlike other UMPs, which were intended to stimulate the recovery, the first QE program in the crisis was undertaken to thaw the frozen credit markets (Bernanke 2009; Boyson et al. 2013). Firms that suffered most from the frozen market were those with high rollover risk. Rollover risk arises when firms have to finance maturing debt in a tight credit market when credit risk premia are high (Diamond 1991) or liquidity premia are high (e.g., He and Xiong 2012). Refinancing at high cost destroys firms' value; hence, it may be optimal for firms to default (Titman 1992). Alternatively, if credit rationing happens, then firms cannot refinance (Stiglitz and Weiss 1981). Therefore, if the first round of QE were useful for the corporate credit markets, firms with higher rollover risk should experience larger decreases in credit spreads.

Hypothesis 2 (a): QE 1 relieved rollover risk.

UMPs could also be more helpful for high-quality firms because of asset-substitution. As reviewed above, QE and OT reduced Treasury rates through the preferred-habitat/ portfolio balance channel, suggesting that their effects only spill over to financial assets that were close enough to what were purchased by the Fed. Moreover, crises often involve flight-to-quality (e.g., Erel et al. 2012; Bai et al. 2012), indicating that the liquidity injected by the QE programs might mainly flow to safe assets rather than assets with high credit risk.

Hypothesis 2 (b): UMPs helped high-quality firms more than low-quality firms through the asset substation channel or the flight-to-quality channel.

Alternatively, by depressing risk-free rates using UMPs, the Fed expected investors would reach for yield and reinvest in riskier assets such as corporate bonds (Rajan 2013). Becker and Ivashina [2014] find supportive evidence that investors intend to reach for yield. They find that, within each rating category, insurance companies tend to hold higher-yield assets. Therefore, if reaching-for-yield is the working channel, then UMPs could increase the demand for securities issued by riskier firms, which in turn decreases these firms' CDS spreads. Part three of the second hypothesis is as follows:

Hypothesis 2 (c): The CDS spreads of riskier firms experienced greater drops because of a reaching-for-yield.

Finally, UMPs might increase long-term investments by lengthening corporate debt maturities. The demand from preferred-habitat investors drives the long-term interest rates abnormally low when the Fed decreases the supply of long-term Treasuries. Because of their limited capital, arbitragers cannot completely remove the mispricing. Given the mispricing, firms issue long-term corporate bonds to fill the gap (Greenwood et al. 2010). Using Compustat data on debt structure, Greenwood et al. [2010] find that the fraction of long-term corporate debt (>1 year) to total corporate debt is negatively correlated with long-term government bond supply at both the aggregate and the individual firm level, supporting the theory. Using corporate debt issuance data, Badoer and James [2014] show that the high-quality firms fill the “gap" in government securities in the very long term.

Therefore, if QE purchases were large enough to create a “gap” in the average Treasury maturity, firms could have extended their borrowing maturity. However, firms incur costs when they switch maturity to fill the “gap;" therefore, they will only react to changes in the Treasury market when the interest saving is sufficient to compensate the cost. Put differently, the higher the fraction of preferred-habitat investors, the larger the changes in interest rates, and the more likely firms will fill the “gap." Therefore, I test the following hypotheses:

Hypothesis 3 (a): QE and OT significantly reduced the average Treasury maturities.

Hypothesis 3 (b): The fraction of preferred-habitat investors is sufficient to lead firms to extend borrowing maturities.

Alternatively, the market-timing theory predicts that firms would issue long-term debt when term spreads are low. Firms face an upward-sloping credit yield curve. Using sets of bonds issued by the same firm, but of different maturities, Helwege and Turner [1999] find that the credit yield curve is upward-sloping for both investment-grade (IG) and high-yield (HY) firms. Meanwhile, firms try to maximize short-term earnings (Stein 1996) by issuing long-term debt when term spreads are low. This statement is supported by the empirical evidence that debt maturity is shorter when the slope of the yield curve is steeper (e.g., Guedes and Opler 1996; Barclay and Smith Jr 1995) and by the survey evidence showing that managers want to issue short-term debt when the short-term rate is low (Graham and Harvey 2001). Therefore, part three of the third hypothesis is as follows:

Hypothesis 3 (c): UMPs that significantly flattened the yield curve could lengthen corporate bond maturity.

1.3 Methodology

The impact of UMPs on credit spreads

To investigate how UMPs affected credit spreads, I employ an event-style two-step panel regression to estimate the changes in credit risk premia, liquidity risk premia, and "fear" premia during each announcement events. The event study method is commonly used in the UMP literature. For example, Gagnon et al. [2010] use event studies to evaluate the effect of QE on interests rates; Swanson et al. [2011] use this method to study the impact of the 1960 Operation Twist; and Krishnamurthy and Vissing-Jorgensen [2011] use event studies to evaluate the impact of QE on corporate bond yields and credit risk spreads.

In the first step, I estimate the sensitivity of changes in individual firm CDS spreads to changes in credit risk (proxied by Baa-AAA spreads), liquidity risk (proxied by the spreads between off-the-run and on-the-run 10-year Treasuries), and "fear" index (VIX).[5,6] A difference-in-difference method is used to control for unobservable risk factors and time-series autocorrelation. The variables suggested by the Merton model, namely the leverage ratio, individual volatility, and the risk-free rate, are also controlled. The following equation is estimated on a rolling basis:

$$\Delta CDS_{i,t} = \alpha + \beta_1 \Delta Baa\_AAA_t + \beta_2 \Delta on\_off_t + \beta_3 \Delta VIX_t + \beta_4 \Delta T10_t + \eta \Delta mklev_{i,t} + \lambda \Delta vol_{i,t} + \varepsilon_{i,t} \tag{1.1}$$

where all changes are non-overlapping log 2-day changes from day t-1 to t+1; ΔCDS_{it} is the log 2-day change in 5-year CDS spreads ($log(CDS_{t+1}/CDS_{t-1})$) for firm i; ΔBaa_AAA_t is the log 2-day change in MoodyâĂŹs' Baa-AAA spreads; Δon_off_t is the log 2-day change in the spread between 10-year off-the-run and on-the-run Treasuries; ΔVIX_t is the log 2-day change in VIX; $\Delta T10_t$ is the log 2-day change in yields on 10-year constant maturity Treasury securities; $\Delta mklev_{it}$ is the log 2-day change in the market leverage ratio; and Δvol_{it} is the log-2 day change in option-implied volatility. This equation is estimated for each firm each day using data in the window [t-180,t-1].

Then, I use the estimated β_1-β_4 in the second-stage regression to study how UMPs changed each risk premium. The following equation is estimated:

$$\Delta CDS_{i,t} = \alpha + \sum_{k=1,j=1}^{k=4,j=16} \Delta\gamma_{k,j}\beta_{k,i,t} * Event_{j,t} + \sum_{j=1}^{16} \theta_j Event_{j,t} + \sum_{k=1}^{4} \eta_k \beta_{k,i,t} + \kappa Control_{i,t-1} + \varepsilon_{i,t} \tag{1.2}$$

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[5] This paper focuses on CDS spreads rather than the yield spreads between corporate bonds and Treasuries because these yield spreads have trading liquidity components (e.g., Longstaff et al. 2005) that are more substantial in the crisis (e.g., Dick-Nielsen et al. 2012). Therefore, CDS spreads are cleaner measures of the required returns of bearing corporate default risks and serve the purpose of this paper better.

[6] Two-day changes in CDS spreads are used to study the "event" effects of QE announcements. On the one hand, as the financial crisis is turmoil, long event window will introduce too much noise. On the other hand, CDS contracts are not as liquid as equities. Therefore, the event window is set to be [-1,+1].

where $\beta_{k,i,t}$, k=1 to 4, are βs calculated in Equation 1.1 for each firm i on each day; $Event_j$, j=1 to 16, includes the sixteen QE event dummies listed in Appendix 2, from the first QE announcement on November 25, 2008 to the second OT announcement on June 19, 2012, and $Event_{j,t}$ equals one if day t is an event date; $Control_{i,t-1}$ includes asset, market-to-book ratio, market leverage, tangibility, and profit (see Appendix 1 for detailed variable definitions). Other variables are the same as in Equation 1.1. This equation is estimated using ordinary least squares, with firm-fixed effects.

Intuitively, if CDS spreads are the products of beta risks multiplied by risk premia, then changes in CDS spreads are the products of beta risks multiplied by changes in risk premia. If any UMP event reduced a risk premium, $\Delta\gamma$ on credit risk, liquidity risk, or VIX is expected to be negative during that event.

The heterogeneous impact of UMPs on firms

I proceed by testing the second hypothesis that the impact of UMPs was different on firms with different rollover risk and quality. To achieve this goal, I investigate the relationship between changes in credit spreads and firm characteristics during UMP announcements using the following equation:

$$\Delta CDS_{i,t} = \alpha + \sum_{k=1,j=1}^{k=8,j=16} \beta_{k,j} Firm\ Characteristics_{k,i,t-1} * Event_{j,t} + \sum_{j=1}^{16} \theta_j Event_{j,t} + \sum_{k=1}^{8} \eta_k Firm\ Characteristics_{k,i,t-1} + \kappa Control_{i,t-1} + \varepsilon_{i,t} \quad (1.3)$$

where $Firm\ Characteristics_{k,i,t-1}$, i=1 to 8, include maturing long-term debt, Roll (individual bond liquidity measure), log asset, distance-to-default, market-to-book ratio, market leverage ratio, tangibility, whether a firm is a potential user of commercial paper, and whether the firm has a financial business segment.[7] CP user equals 1 if the firm has an S&P short-term debt rating of A-1+, A-1, or A-2 and zero otherwise. Fin segment equals 1 if the firm reports a business segment with an

[7]Distance-to-default is calculated using Merton model. Thanks to Yongqiang Chu for generously providing this variable.

SIC code between 6000 and 6999 in the recent fiscal year and zero otherwise. This equation is estimated using ordinary least squares, with firm-fixed effects.[8]

If a UMP helped a specific type of firm, such a firm should experience a larger decrease in CDS spreads during the event.

UMPs and corporate bond maturities

I compare the average corporate bond maturity in both UMP and non-UMP periods using the following equation:[9]

$$Bond\ maturity_{i,t} = \alpha + \beta UMP\ dummies_t + \gamma Recession_t + \eta Controls_{i,t-1} + \varepsilon_{i,t} \quad (1.4)$$

where *Bond maturity*$_{it}$ is the log of bond issuance maturity in month t for firm i. Key independent variables are UMP dummies, including QE 1, QE 2, and FG/OT; QE 1 is a dummy variable that equals 1 if the bond was issued between March 2009 (when the first QE announcement regarding the purchase of Treasuries was made) and October 2009; QE 2 is a dummy variable, which equals 1 if the bond was issued between November 2010 and June 2011; FG/OT is a dummy variable that equals 1 if the bond was issued between August 2011 and December 2012. Because the FG and OT periods largely overlapped, I only define this period as FG/OT. *recession* is the NBER recession dummy. *Controls* include firm age, firm size, yearly stock return before bond issuance, credit rating, market to book ratio, profitability, tangibility, asset maturity, RND, asset volatility, and leverage ratios.

[8]Because the 2007-2009 crisis was related to subprime mortgages, and QE involved the purchase of MBS, this paper also considered whether a firm reported a real-estate segment. None of the firms in the sample reported such a segment in Compustat.

[9]This paper studies bond maturity instead of bank loan maturity for the following two reasons: (1) while most bonds are of fixed rates, bank loans are more of floating rates, which make their maturities less sensitive to long-term interest rates; and (2) bank loan maturities are less likely to subject to firms' discretion. As stated by Thomson Reuters, which is the data provider of syndicated bank loans, investment-grade firms only draw down credit lines when something happens; and the maturity of revolving loans of high-yield firms is mostly restricted to one year because of capital reserve requirements on the bank side.

To test Hypothesis 3 (a), I compare the average Treasury maturity before and after considering the Open Market Operation (OMO). Then, I test the gap-filling channel in Hypothesis 3 (b) and the market-timing channel in Hypothesis 3 (c) using the following equation:

$$\begin{aligned} Bond\ maturity_{i,t} =& \alpha + \beta_1 Treasury\ maturity_t + \beta_2 Preferred - habitat_t \\ & + \beta_3 Treasury\ maturity_t \times Preferred - habitat_t + \beta_4 Term\ spread_t \\ & + \beta_5 Timetrend_t + \beta_6 Recession_t + \gamma Controls_{i,t-1} + \varepsilon_{i,t} \end{aligned} \tag{1.5}$$

where $Treasury\ maturity$, following Greenwood et al. [2010] and Badoer and James [2014], is the weighted average maturity of outstanding principal and coupon payments of US Treasuries; $Preferred - habitat_t$ is the fraction of preferred-habitat investors in the corporate bond and Treasury market; $Timerend$ is calculated as $(year - 1989) * 12 + month$ to control the decreasing trend in corporate bond maturities (Custódio et al. 2012).

The gap-filling theory predicts a negative β_1; if Hypothesis 3 (b) holds, then β_3 is expected to be negative; and the market-timing theory predicts a negative β_4.

1.4 Data and Sample

Data on US non-financial firms are from Markit Inc., Compustat, the Center for Research in Security Prices (CRSP), OptionMetrics, Mergent FISD, and TRACE. Data on outstanding Treasury securities are from Mergent FISD, TreasuryDirect, and Open Market Operation. Data on the investor composition of Treasuries and corporate bonds are from Flow of Funds. I collect the UMP announcement dates based on FOMC statements and minutes releases, and I also refer to the discussions in Krishnamurthy and Vissing-Jorgensen [2011] and Fawley and Neely [2013]. A detailed description of the event dates studied in this paper is in Appendix 2.

CDS data and variables

Single-name CDS data are from Markit Inc., one of the leading CDS data providers. Their pricing inputs are from multiple industry practitioners and observable pricing sources with data cleaning processes applied to remove outlying or stale inputs. I use 5-year CDS data, which are most liquid.[10] I further restrict the sample to CDS spreads on senior debt and the "MR" term. The sample period is between June 2005 and June 2012. The original sample has 778 non-financial firms with Compustat and CRSP identifiers. To mitigate the survival bias, I only keep firms that have more than 566 trading days, thus excluding one quarter of the firms. To study CDS changes, only the "most liquid" firms are included in the sample, thus excluding firms with more than 70% days with zero changes (5% of the entire sample) and more than 35% days with zero 2-day changes (10% of the whole sample). Next, 142 firms are deleted because they never had valid TRACE data in the entire sample period (needed to construct individual bond liquidity). Finally, I also require firms to have option-implied volatilities from OptionMetrics. The final sample has 321 firms, of which 64.5% are of investment grades. This sample covers firms with a wide range of credit quality, with the number of firms and rating distributions not significantly different from year to year (Table 1.1)

Following Ericsson et al. [2009], I use a 45-day rule to match CDS data with quarterly Compustat data, assuming that financial reports are not available until 45 days after each fiscal quarter. Market leverage ratios are calculated each day using stock prices in CRSP and quarterly accounting data in Compustat. OptionMetrics offers option-implied volatility on various terms.[11] All variables are winsorized at the

[10] Ideally, 1-year CDS would fit the study better because 1-year CDS puts more weight on near-term credit risk. However, 1-year CDS contracts are illiquid that they are not suitable for event studies in this paper. I use 5-year CDS to generate benchmark results and 1-year CDS to conduct robustness checks.

[11] To make consistent estimates, I only keep the option contracts that mature in the following month and have a delta closest to 0.5 (-0.5). Then, I take the average value of the volatility implied

1% and 99% levels. On average, the logged asset size is 9.25, which is larger than the average firm size in Compustat. The average market leverage ratio is 21.1%, and the average market-to-book ratio is 1.64, both of which are close to those of firms in Compustat.

Regarding the rollover risk measures, this paper use long-term debt maturing in one year and bond liquidity measure (Roll). Measuring effective bid-ask spreads, Roll is constructed following Bao et al. [2011] using TRACE-enhanced bond transaction data, which reports uncapped trading volume but has an 18-month reporting lag. For easy interpretation, the Roll measure is standardized to have a sample mean of zero and a standard deviation of one. Higher Roll denotes higher bid-ask spreads and, therefore, lower liquidity. On average, the fraction of maturing long-term debt in one year decreased in 2009 and 2010 and then picked up. Bonds were most illiquid in 2008 and 2009. At the beginning of 2008, 36 of 295 firms had the ratio of maturing long-term debt over total long-term debt ratio larger than 20%. The number of firms with high rollover risk was approximately half of the 87 firms identified by Almeida et al. [2009] using whole Compustat data.

The market conditions include Moody's Baa-AAA spreads, spreads between 10-year off-the-run and on-the-run Treasuries, VIX, and 10-year Treasury rates. Moody's Baa-AAA spreads are from the Federal Reserve H.15, where higher Baa-AAA spreads are associated with higher credit risk premia. Spreads between 10-year off-the-run and on-the-run Treasuries are from the Citi Yield Book, where higher spreads suggest higher market liquidity premia. VIX is from the Chicago Board Options Exchange (CBOE), where an increased VIX means that investors are more worried about the economic outlook. It is also known as the "fear" index. Ten-year Treasury rates are interest rates of 10-year constant maturity Treasuries from the Federal Reserve H.15, where higher Treasury rates are usually associated with better economic conditions.

by a call option and a put option as the option-implied volatility.

Indeed, as shown in Table 1.2, the changes in 5-year CDS spreads and market condition indicators during most of UMP announcement days are economically large. They are close to the 10th or 90th percentiles in the whole sample (Table 1.1 Panel C). On average QE easing announcements decreased CDS spreads, and tapering announcements increased CDS spreads. The effect of QE 1 is much stronger than that of QE 2. Considering that the 10th/90th percentiles of historical log 2-day changes in CDS spreads are - 4.09% and 4.27%, the changes in CDS spreads on UMP announcements are economically significant. On average, FG decreased CDS spreads, and OT increased CDS spreads. The changes in log 2-day CDS spreads for IG firms are not very different from those of HY firms.

Debt maturity data and variables

The detailed outstanding Treasury data are from three sources. Mergent FISD, which is a comprehensive database of publicly offered US bonds, provides detailed Treasury issuance and outstanding amounts for all bills, notes, and bonds since mid-1995. Treasury issuances and outstanding amounts before 1996 are collected from the Monthly Statement of the Public Debt, provided by TreasuryDirect. To estimate the maturity and quantity changes caused by the QE programs, I collect detailed data on the purchase of Treasury securities by the Federal Reserve Bank of New York through the OMO. Following Greenwood et al. [2010], I consider both principal and coupon payments. The Treasury sample consists of 278 monthly observations between 1990 and 2012.

Corporate bond issuance data are from Mergent FISD. I include all the US non-convertible industrial bonds issued between 1990 and 2012 with Compustat identifiers.[12] The original data include 22,197 bonds issued by 2,536 firms. The mean

[12] My sample does not include the years before 1990 because the bonds matured before 1990 are not included in the Mergent FISD. Including data before 1990 may thus introduce a mechanical decreasing trend in the bond maturity.

issuance maturity is 9.94 years, and the median is 9.03 years. After being matched with Compustat quarterly data, 15,476 bond issuances with non-missing variables are left. The observations are lost mainly because of missing market value and asset maturities. I further collapse the data to one observation per firm-month. The dependent variable, the maturity of bonds, and the control variables are monthly averages, weighted by the issuance amount. The collapsed data avoid putting too much weight on firms that issue many times in a month.

The final corporate bond sample consists of 8,346 firm-month observations between 1990 and 2012. My sample is comparable in size to that used by Erel et al. [2012], which consists of 7,523 firm-month observations between 1985 and 2007. IG firm-month observations account for 60% of the sample.

A key variable used in the test is the fraction of preferred-habitat investors. Greenwood and Vayanos [2010] and Chen et al. [2012b] suggest that preferred-habitat investors should be defined as property-casualty insurance companies, life insurance companies, private pension funds, state and local government employee retirement funds, and federal government retirement funds. Flow of Fund L209 and L212 tables provide quarterly information on Treasury and corporate bonds held by each sector. As shown in Figure 1.1, the proportions of preferred-habitat investors in both the Treasury and the corporate bond market have dramatically decreased in the past two decades. This change is not caused by the shrinkage of the preferred-habitat capital because there is no clear decreasing pattern for the percentage of preferred-habitat investors over GDP (Figure 1.1).

1.5 The Impact of UMPs on CDS Spreads

In this section, I first discuss how each UMP affected the credit risk premia, liquidity risk premia, and "fear" premia components of CDS spreads. Then, I discuss two alternative explanations of how UMP could have increased CDS spreads.

How did UMPs affect CDS spreads?

I use a two-step event-style panel regression to study the changes in CDS spreads during each UMP event. In the first step, I use Equation 1.1 to estimate rolling risk exposures regarding market credit risk, liquidity risk, and the "fear" index for each firm. As shown in Table 1.3 Panel A, the changes in the independent variables are not highly correlated, except the changes in VIX and the 10-year Treasury rate. The -0.35 correlation between changes in VIX and the 10-year Treasury rate is consistent with the argument that low risk-free rates are usually associated with economic downturns (Collin-Dufresne et al. 2001; Ericsson et al. 2009). The summary statistics of the estimated covariance risks (βs) are shown in Table 1.3 Panel B. On average, firm CDS spreads positively correlate with market credit risk, liquidity risk, and the "fear" index, but they negatively correlate with 10-year Treasury rates. The average positive relationships are intuitive in that the increase in market credit risk, market illiquidity, and "fear" about future growth inflate default risk and risk aversion, which in turn increase CDS spreads. The negative relationship between CDS spreads and the 10-year Treasury rate is consistent with the literature (Collin-Dufresne et al. 2001; Ericsson et al. 2009). A possible explanation for the inverse relationship is that lower risk-free rates are associated with expanding monetary policies and a weak economic outlook.

Then, in the second step, I use the estimated risk exposures in the first step to study the changes in credit risk premia, liquidity risk premia, and "fear" premia.[13] The estimation results are presented in Table 1.4. Because dependent variables take the form of log changes, the coefficients reported in Table 1.4 can be interpreted as the percentage changes in risk premia. QE 1 announcements decreased the credit risk

[13]Because the negative empirical relationship between 10-year Treasury rate and CDS spreads does not mean that a decrease in 10-year Treasury rates increases CDS spreads (Gilchrist and Zakrajšek 2013), this paper only estimates the "risk-free rate premia" for control purposes without further analysis.

premium by 2-5% and the “fear” premia by 5-13%. The initial QE announcement decreased the liquidity premium by 20% and the interest rate risk premium by approximately 7%. The first two QE 2 announcements that indicated the stimulation but not a plan increased the “fear” premia significantly by more than 10%, while the third QE 2 that specified the size of the second round of QE purchase decreased the “fear” premia. The empirical results on QE 1 and 2 suggest that the UMPs in the crisis reduced credit risk premia, liquidity premia, and “fear” premia. However, the UMPs after the crisis, especially those with unclear statements, may have delivered the information of a weak economic outlook, which resulted in higher credit spreads.

The results on OT further confirmed that the UMPs during the recovery period could have persuaded investors that the economy was weaker than they had expected. Hence, the credit spreads increased during the OT announcements. In contrast to QE and OT, the FG that eliminate the uncertainty in FF rate policies for two years decreased credit risk premia and “fear” premia. The results indicate that FG was effective with little cost.[14]

To estimate the economic significance, this paper further decomposes changes in average CDS spreads to components due to changes in each risk premia during each announcement (Table 1.5). The results show that changes in these risk premia explain a significant fraction of average changes in CDS spreads during those expanding policy announcements (from 31% to 139%, with a mean of 60%). The increase in average CDS spreads during the 2011 FG was abnormal that it could not be explained by changes in risk premia studied in this paper.

[14]The estimated independent variables (risk exposures-βs) may lead to biased estimations. To deal with this issue, I re-estimate Equation 1.2 using βs weighted by their standard errors (Table C.4), which does not change the quality of the results. Still, the coefficients in Table 1.4 may be biased toward insignificant because of attenuation errors. However, in most cases, the signs of the insignificant coefficients are in line with the arguments in this paper.

Two alternative explanations

The first alternative explanation of why CDS spreads increased on QE 2 announcements is that the size of the QE 2 purchase failed market expectation. This explanation is not supported by the results in this paper. In particular, average CDS spreads increased during the first two QE announcements, in which the Fed did not mention the size of the new stimulus. Furthermore, average CDS spreads decreased during the third QE 2 announcement, in which the Fed announced the size and the asset they would purchase. These empirical results contradict the prediction of the first alternative explanation.

The second alternative explanation is that other events may contribute to the findings in this paper. In particular, the Euro Crisis (occurring before the QE 2 announcements) and the US credit downgrade (occurring before the announcement of FG and OT) might have increased CDS spreads on average. In such cases, the changes in "fear premia" found in this paper might have just picked up the legacy of the Euro Crisis and the US credit downgrade, among other events. To mitigate this concern, this paper investigates the "fear" index during a 10-day window surrounding each UMP announcement. As shown in Figure 1.8 (a), all QE 1 announcements, except the Bernanke Speech on 12/1/2008 (QE 1_2), slightly decreased the "fear" index. The most supportive evidence that the changes in "fear premia" found in this paper were caused by UMP announcements comes from QE 2, OT, and FG (Figure 1.8 (b)-(d)). In particular, the VIX was relatively stable within 5 days before each QE 2 and OT announcements; and, in contrast, it sharply changed after these announcements. Moreover, the first FG announcement obviously reversed the increasing trend in the VIX.[15] Last, the plots of the S&P 500 index mirror the plots of the VIX and support

[15]It is not surprising that the second OT announcement and the second FG announcement had minimal effect on VIX because these two announcements did not add much new information. The second OT announcement extended the size of the OT from $400 billion in Treasuries to $600 billion, and the second FG announcement reinforced that the low Fed Funds rate would continue for a long

the argument in this paper that UMP announcements shaped the expectations about future growth and, consequently, affected the "fear" premia in CDS spreads.

Overall, the empirical results support the first two parts of Hypothesis 1 that UMPs could reduce credit spreads by reducing credit risk premia and liquidity risk premia; they also support the third part of Hypothesis 1 that UMPs could increase credit spreads by creating a "fear" premia. The positive effects are more likely to happen in a crisis, and the negative effects tend to dominate in a recovery period.

1.6 Which Firms Did UMP Announcements Help More?

This section discusses what type of firms each UMP announcement helped more in order to understand the channels of different UMPs. Using an event-style panel regression, I study the impact of rollover risk (measured by long-term maturing debt and Roll), asset size, market-to-book ratio, leverage ratio, distance-to-default, whether a firm is a potential commercial paper user, and whether a firm reports a financial segment on CDS spreads during each announcement. While the maturing long-term debt measures the refinancing pressure in general, Roll measures the rollover risk caused by illiquid bond and illiquid credit markets. If an event relieved the refinancing pressure, then firms with higher rollover risk should experience larger decreases in CDS spreads. If UMPs worked through the substitution channel or drove investors to securities issued by high-quality firms, then firms with a larger size, lower leverage, or higher distance-to-default should experience larger decreases in CDS spreads. Alternatively, if UMPs targeted on the short-term debt market or the financial industries, then firms with a commercial paper rating or a financial segment should have larger drops in CDS spreads, respectively.

The most significant results come from asset size (Table 1.6). In particular, when

time.

a UMP decreased CDS spreads on average, the CDS spreads of the larger firms decreased more, and vice versa. A one standard deviation increase in asset size is associated with an approximately 1% greater decrease (increase) in CDS spreads in QE 1 and FG (QE 2 and OT) announcements. The results suggest that UMPs were more effective to large firms. These results could be explained by the empirical findings that the CDS spreads of larger firms are more sensitive to changes in macroeconomic conditions (Table C.3). This relationship holds after controlling for the liquidity of CDS contracts.

Furthermore, the results in Table 1.6 show that the fifth announcement in QE 1 that specified the schedule and size of the Treasury purchase relieved the refinancing pressure caused by individual bond illiquidity and market illiquidity (Roll). A one standard deviation increase in Roll, which is 1, is associated with a 0.7% larger decrease in CDS spreads. Given that the average decrease in CDS spreads on this QE announcement is 2.58%, the impact of rollover risk is economically significant. The announcement of agency debt and MBS purchase (QE 1_1) did not have such an impact, nor did the announcement of the intention to buy Treasuries (QE 1_3 and QE 1_4). Although the coefficients on maturing long-term debt during QE 1 and 2 are also negative in general, they are not significant. The results indicate that QE 1 could relieve the rollover risk caused by market illiquidity; however, this result might only be achieved through the purchase of Treasuries, which were closer substitutes for corporate bonds.

Lastly, the results also support the flight-to-quality and reaching-for-yield arguments. In the first announcements of QE 2 and OT that significantly increased the “fear” premia, safer firms with higher distance-to-default experience smaller increases in CDS spreads, with a one standard deviation increase in distance-to-default (4.7) associated with a 1.5% lower increase in CDS spreads. This result is consistent with the flight-to-quality statement. In contrast, the second FG announcement that significantly reduced the “fear” premia decreased CDS spreads more for firms with higher leverage ratios, with a one standard deviation increase in the leverage ratio (0.13) associated with a 0.6% larger decrease in CDS spreads. This result is consistent with the reaching-for-yield argument. Given that the average changes in CDS spreads in the first announcement of QE 2, the 2011 OT, and the 2012 FG announcements were 3.6%, 5.09%, and 3.01%, respectively, the coefficients of distance-to-default and leverage ratios are economically significant. Because the first announcements of all UMPs were the most unexpected, their effects should be more prominent. The reason FG in 2012 had a larger impact on reaching-for-yield could be that the Treasury yields at 2012 FG were much lower than those at 2011 FG, which gave investors more incentive to reach for yield.[16]

Overall, I find some evidence that UMPs relieved the rollover risk in the worst time. Furthermore, in the post-crisis period, the UMPs that increased the “fear” for another downturn drove investors’ flight-to-quality; the UMPs that decreased the “fear” and reduced the risk-free rates spurred reaching-for-yield.

1.7 The Impact of QE on Bond Maturity

Next, I examine how QE programs might have affected corporate credit markets by changing corporate bond maturities using a firm-month panel of new bond issuance data between 1990 and 2012. Because most firms do not issue bonds very often, I have an unbalanced panel. For the 1,971 firm-month observations where firms issue more than one bond in a month, the median (mean) number of issuances per month is 2 (3), and the maturity is calculated as the average of bond maturities weighted by the offering amount of each bond. I examine how the corporate bond issuance

[16] The empirical studies in the previous section and this section use log 2-day changes in 5-year CDS spreads as measures of changes in credit spreads. These results are robust to using 1-year CDS spreads or absolute changes in CDS spreads as dependent variables.

maturity has changed in UMP periods and then explore channels leading to these changes.

Corporate bond maturity in QE periods

I start by comparing corporate bond maturities in both UMP and non-UMP periods. On average, firms did not extend borrowing maturities in QE 1 and 2 periods (Table 1.8). Only IG firms extended borrowing maturities in the FG/OT period, while HY firms did not extend borrowing maturities at all.

Table 1.8, Column 1 presents the estimations of Equation 1.4 using the whole sample. With market conditions and firm characteristics controlled, the average corporate bond issuance maturity was shorter in the QE 1 and 2 periods and not different from other times in the FG/OT period. Because IG firms may respond to QE programs more aggressively than HY firms (Greenwood et al. 2010), I further estimate the equation using IG and HY subsamples separately. Table 1.8, Columns 2 and 3 display these results, showing that IG firms did not extend the borrowing maturity until the FG/OT period and that HY firms always borrowed in the shorter-term in QE periods. On average, IG firms extended bond issuance maturities by 1.2 years in the FG/OT period.

Additionally, consistent with Erel et al. [2012], I find that firms issue debt in the shorter-term during recessions because of flight-to-quality. Consistent with the information asymmetry arguments in Flannery [1986] and Diamond [1991], debt maturities are hump-shaped across credit ratings. For HY firms, debt maturity increases with investment opportunity to avoid liquidity risk (Diamond 1991; Diamond and He 2012). Consistent with most of the existing empirical literature, debt maturity increases with asset maturity. For HY firms that have high liquidity risk, I find that their debt maturities increase with asset volatility. Regarding leverage ratios, I show that debt maturities decrease with leverage ratios. The result is consistent with studies that rely on bond issuance data (e.g.,Custódio et al. 2012) and is contrary to the research based on balance sheet data (e.g., Stohs and Mauer 1996; Chen et al. 2012a). The comparable coefficients of the control variables in Table 1.8, Columns 1 and 4 indicate that QE effects are unlikely to be caused by changes in firm characteristics.

Because the average corporate bond issuance maturity was longer in the 1990s than in the 2000s (Custódio et al. 2012), I re-estimate the equation only using bonds that were issued after 2000 to mitigate the sample selection bias. These results are presented in Table 1.8, Columns 5 through 7, which are similar to my main results.[17]

Preferred-habitat and gap-filling channel

Second, I examine the two conditions for QE to change corporate bond maturities through the preferred-habitat and gap-filling channels.

The first condition is that QE had to lower the average Treasury maturity effectively to create a gap for firms to fill in. Figure 1.8 shows the changes in outstanding Treasury securities before and after accounting for the Fed's purchases. The total amount of outstanding publicly-held Treasury securities nearly doubled, from less than \$6 trillion before the crisis to more than \$10 trillion in 2012. QE 1 and 2 purchases did not reduce the average Treasury maturity due to net Treasury issuance.[18] In contrast, OT reduced the average Treasury maturity and, therefore, might have induced firms to issue longer-term debt to fill the "gap."

The second condition is that the fraction of preferred-habitat investors has to be sufficient for firms to react to the changes in Treasury maturities. I first examine

[17] Although not reported here, the results for HY & NR firms in columns three and four do not change the quality if I exclude non-rated bonds from the sample. In unreported tables, I redefine QE 1 as between November 2008 and October 2009 and QE 2 as between August 2010 and June 2011. These specifications yield similar results. I also redefine the beginning date of each QE as one month after each official announcement date to allow responses to occur. The main results still hold.

[18] Following Greenwood et al. [2010], the average Treasury maturity in this paper is calculated using both principals and coupons. Excluding coupons does not change the quality of the results.

this condition by estimating Equation 1.5. Consistent with Greenwood et al. [2010] and Badoer and James [2014], I find that corporate bond issuance maturities are negatively correlated with outstanding Treasury maturities (Table 1.9, Column 1). If this relationship holds unconditionally, the Fed purchases between March 2009 and December 2012, which decreased the log of Treasury maturities by 0.13 (approximately 0.7 years), could have increased the log of average corporate bonds by 0.05 (approximately 0.4 years) on average. However, firms react to changes in Treasury maturities more aggressively when there are more preferred-habitat investors (Table 1.9, Column 2). With the specifications in this paper, preferred-habitat investors need to be approximately 13 of the total investors for the gap-filling channel to work in UMP periods. Starting from the first QE announcement in November 2008, the average fraction of preferred-habitat investors in the Treasury and corporate bond markets is approximately 20%, indicating a non-negative relationship between Treasury maturities and corporate bond maturities. This relationship holds for both IG and HY firms (Table 1.9, Columns 3 and 4).

Because both the average Treasury maturity and the fraction of preferred-habitat investors display significant time trends (Figure 1.1), I also run the regressions using trend-adjusted key independent variables to check for robustness. To achieve this goal, I regress the average Treasury maturity and the preferred-habitat investors on the time trend to obtain residual terms, which are used as new independent variables in Table 1.9, Columns 5 to 7. The results for the impact of preferred-habitat investors are robust.

Because corporate financing policies are endogenous, the decision to issue a bond may also affect corporate bond maturity, introducing a selection bias. To mitigate this bias, I re-estimate Equation 1.5 using Heckman selection models. In the first stage, I regress the issuance dummy variable on the independent variables, using all firms in quarterly Compustat.[19] In the second stage, corporate bond maturities are regressed on the variables of interest. The estimations using Heckman selection models (Table 1.10) are very close to my baseline results (Table 1.9).

Taken together, QE were unlikely to change corporate bond maturities through the preferred-habitat and gap-filling channel for the following reasons: (1) QE 1 and 2 purchases of Treasury did not outweigh the net Treasury issuance; and (2) the relationship between corporate bond maturities and Treasury maturities depends on the fraction of preferred-habitat investors, which might be too low for the relationship to be negative in UMP periods.

Market-timing channel

Finally, I discuss how market-timing could explain changes in corporate bond maturities in UMP periods. The negative coefficients on term spreads and 10-year Treasury rates in Table 1.9 are consistent with the literature, which maintains that firms issue debt in the longer-term when term spreads or interest rates are lower. While overall interest rates were low in the whole QE period (Figure 1.8), Treasury term spreads were mostly historically high in QE 1 and 2 because of the zero FF rate policy (Jarrow and Li 2012). Therefore, these high term spreads might have driven firms to issue shorter-term debt in QE 1 and 2.

However, with increasingly more QE announcements, investors gradually believed that low FF rates would continue in a longer period (Figure 1.8 b).[20] The FG announcement in August 2011 convinced investors that the low FF rate would continue for at least two years, which, according to the expectations theory, dramatically drove down term spreads (Figure 1.8 b). The term spreads between 10-year and 1-year Trea-

[19] I delete firms with quarterly negative assets, negative sales, and long-term debt to asset ratio less than 5%.

[20] Krishnamurthy and Vissing-Jorgensen [2011] shows that each QE announcement in QE 1 and 2 had lengthened the expectation by about one month.

sury yields decreased approximately 130 bps from the announcement of FG in August 2011 to the end of 2012, indicating a 1 (0.2) year increase the log maturity of IG (HY) corporate bonds, respectively.

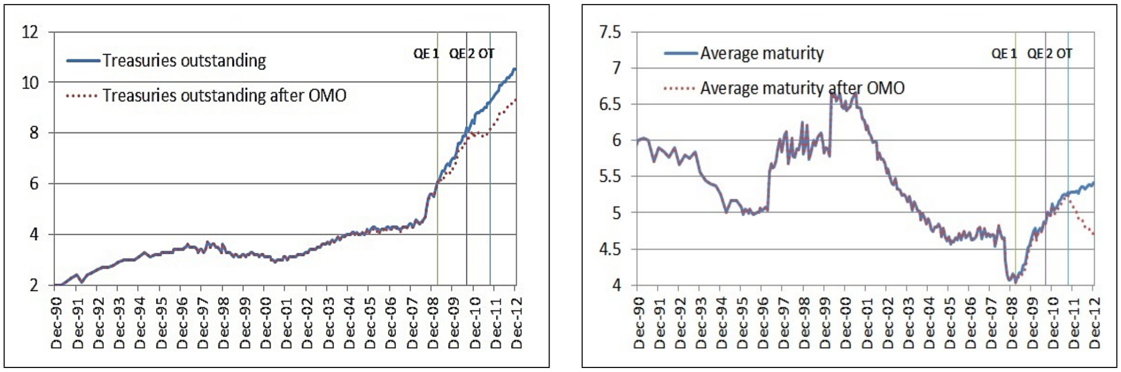
Therefore, the low term spreads and long-term interest rates in the FG/OT period together should have driven corporate bond maturities to the longer domain. This projection is supported by Table 1.8, which shows that IG firms extended the borrowing maturity in the FG/OT period. One possible explanation for why HY firms did not respond is that the term spread of HY bonds does not closely follow the term spread of Treasuries. Figure 1.8 shows that while term spreads of IG bonds closely follow Treasury term spreads, with a correlation of 0.77, term spreads on HY bonds are mostly around zero and sometimes move in the opposite direction, with a correlation of -0.19 between 2002 and 2012.

Overall, QE programs were unlikely to change corporate bond maturities through the preferred-habitat and gap-filling channel. Alternatively, the monetary policies that flattened the yield curve were able to lengthen high-quality firm bond maturities through the market-timing channel.

1.8 Conclusions

This paper studies how UMPs affected corporate credit markets and finds that FG came closest to achieving what the Fed intended. QE 1 reduced credit spreads because it boosted confidence and reduced risk-aversion in the crisis. However, QE 2 and OT increased credit spreads because they stoked the fear of future downturns; as a result, they might have induced a flight-to-quality. In contrast, FG that preset the path of the interest rates decreased risk premia, provoked a reaching-for-yield, and lengthened corporate borrowing maturities. In the crisis, QE affected corporate financing via the substitution channel in that the purchase of Treasury securities, as opposed to mortgage-related securities, decreased corporate rollover risk. In general, the impact of UMPs was most significant to large firms. Regarding corporate bond maturities, I find that firms did not lengthen borrowing maturities in QE 1 and 2, but high-quality firms did in the FG/OT period. The empirical results show that the market-timing channel was more effective than the gap-filling channel in UMP periods.

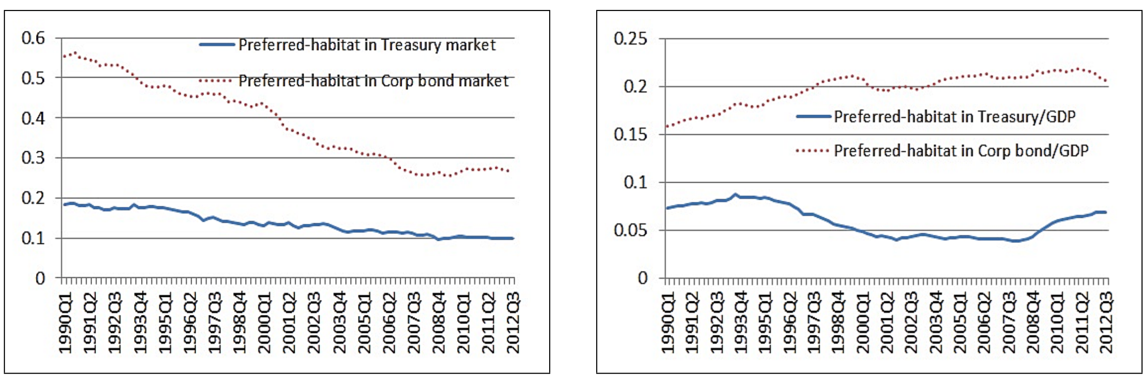
The policy implications are as follows. First, although the UMPs helped calm credit markets in a crisis, these policies could have undesirable consequences in a recovery period, such as increasing the "fear" about another downturn. Second, if implemented creditably, FG could have the most desirable impact in a recovery period. Last, if the Fed intends to help firms that are most in need of refinancing in a crisis, then they could, if allowed, purchase corporate bonds with credit risks.



(a) Outstanding amount (in trillions) (b) Weighted average maturity (in years)

Figure 1.1 Preferred-habitat Investors

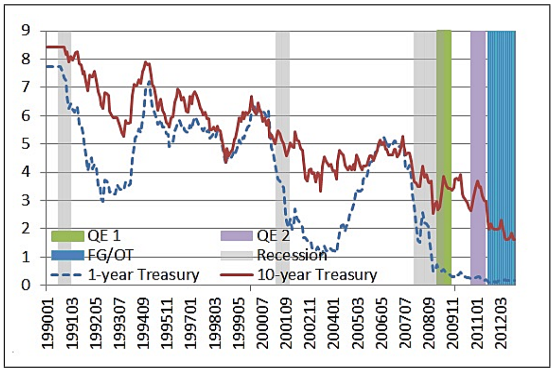
This figure shows the amount of preferred-habitat investors between 1990 and 2012. Preferred-habitat investors include property-casualty insurance companies, life insurance companies, private pension funds, state and local government employee retirement funds, and federal government retirement funds. Data are provided by Flow of Funds.



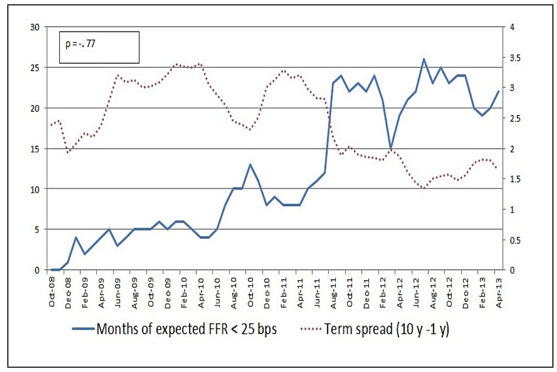
(a) Percentage of preferred-habitat investors in Treausry/corporate bond market (b) Preferred-habitat capital in Treausry/corporate bond market over GDP

Figure 1.2 Treasury Securities Before and After Open Market Operations

This figure shows the total outstanding amount, weighted average maturity, and the fraction of short-term debt of US public-held Treasury securities before and after accounting for the OMO. The vertical line represents the start of the first-round Treasury security purchase, the vertical dot line represents the start of the second-round Treasury security purchase, and the vertical dash line represents the start of the Operation-Twist. The numbers in this figure are calculated using Treasury principals available in Mergent FISD.



(a) Treasury rates (in percentage)



(b) The number of months the FF rate is expected to be below 25 bps (in months)

Figure 1.3 Treasury Rates

Figure (a) shows the interest rates on 10-year and 1-year constant maturity Treasuries. The shaded area represent recessions, QE1, QE2, and FG/OT, respectively. Figure (b) shows the number of months that investors expected the Fed Fund rate to be below 25 bps. The length is calculated using Fed Fund 30-day futures.

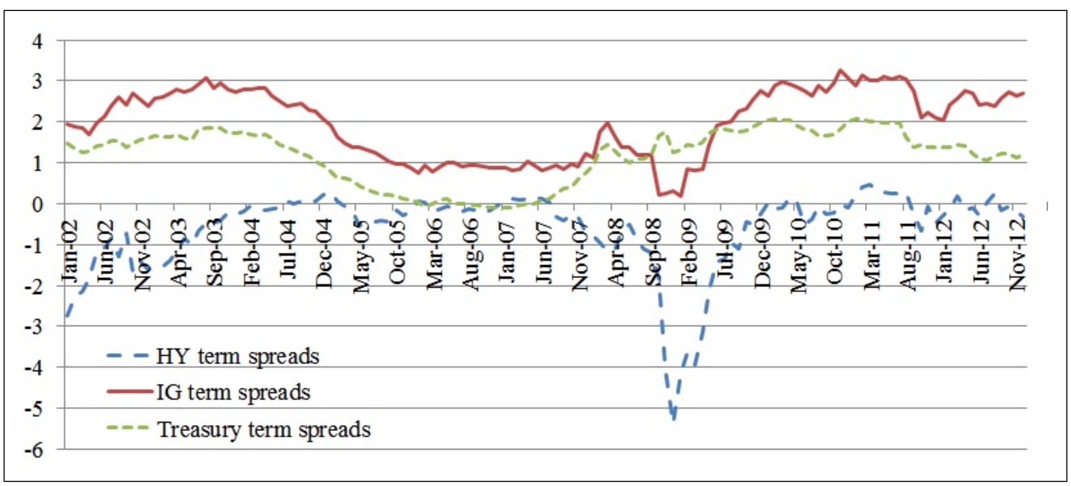


Figure 1.4 Term Spreads

This figure shows term spreads for Treasuries, IG bonds, and HY bonds. The term spread of Treasury is calculated as the difference in interest rates on 10-year and the average of 1- to 7-year bonds for Treasuries. The term spreads of IG(HY) bonds are calculated using industrial corporate bond IG(HY) indices with 10-year and 1-7 years maturities provided by The Yield Book.

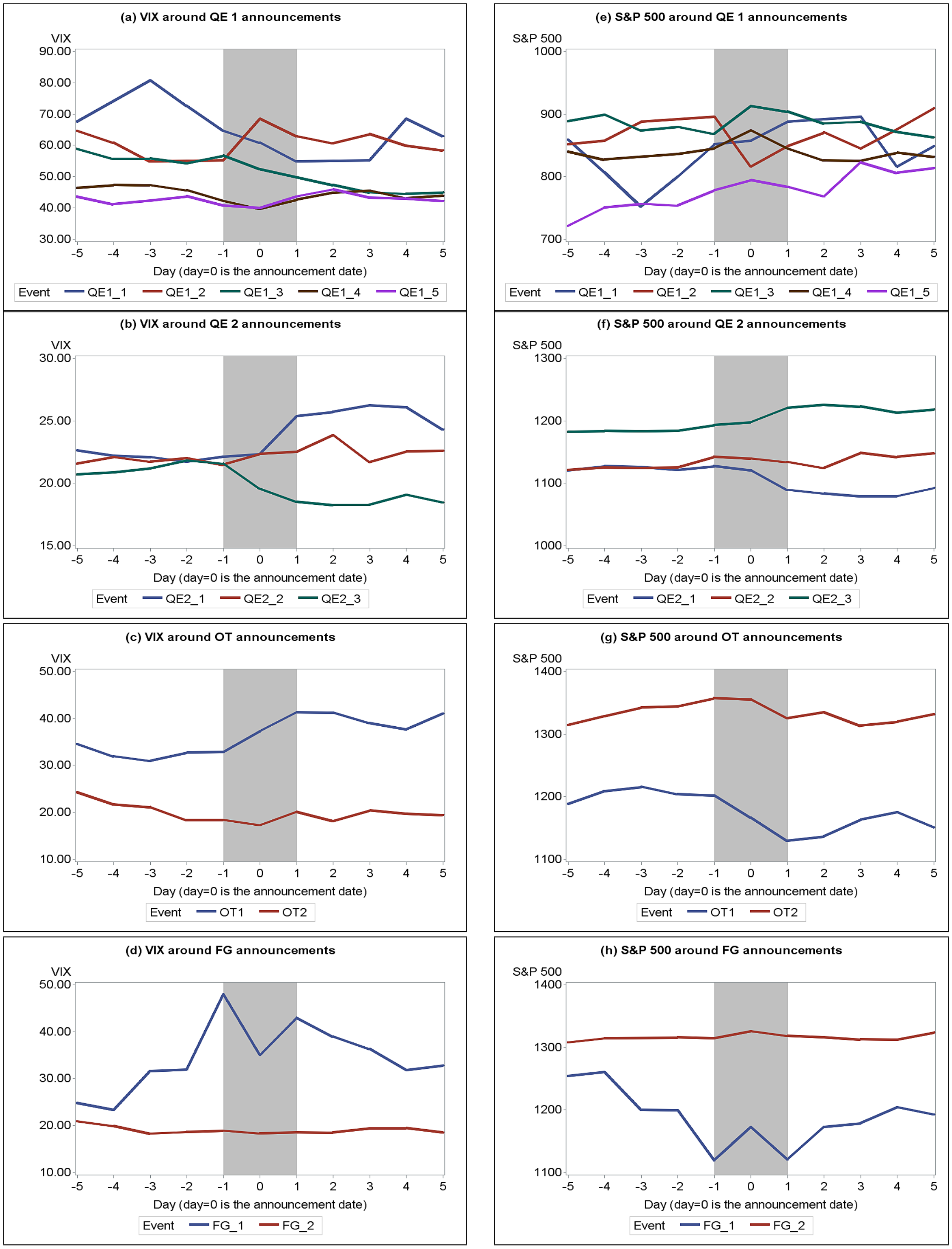


Figure 1.5 VIX and S&P 500 Index Around UMP Announcements

These figures show the VIX and the S&P 500 index during 10 weekdays around the UMP announcements studied in this paper. Figure (a)-(d) show the VIX around QE 1, QE 2, OT, and FG announcements, and Figure (e)-(h) show the S&P 500 index around QE 1, QE 2, OT, and FG announcements. Shaded areas represent two-day windows ([-1,1]) around announcements.

Table 1.1 Summary Statistics of the Credit Spreads Sample

This table presents the summary statistics of the CDS sample. Panel A presents the distribution of firms by credit rating and year. Panel B shows the summary statistics of firm characteristics. dd1_at is maturing long-term debt over asset. Roll is the individual bond liquidity measure, standardized to have a sample mean of 0 and a sample standard deviation of 1. log asset is the log of asset. 5-year CDS is single-name 5-year CDS spreads. dd is "distance-to-default" calculated using Merton model. mk lev is market leverage ratio calculated using daily stock caption. mk2bk is market to book ratio. CP user equals 1 if the firm has an S&P short-term debt rating of A-1+, A-1, or A-2. Fin segment equals 1 if the firm reports a business segment with an SIC code between 6000 and 6999 in the recent fiscal year. Panel C shows the summary statistics of log changes in 2-day CDS spreads and log changes in market condition proxies. All changes take the log form ($log(X_{t+1}/X_{t-1})$). Baa_AAA is the spread between Moody's Baa and AAA index yields. on_off, a market liquidity measure, is the spread between off-the-run and on-the-run 10-year Treasury yields from Citi Yield Book. T10 is the yield on 10-year constant maturity Treasury securities. VIX is the CBOE volatility index.

Panel A. Distribution of firm by year and rating

Year	AA	A	BBB	BB	B	C	Total
2005	48	67	61	46	31	15	268
2006	47	68	63	51	37	16	282
2007	48	69	71	52	40	17	297
2008	49	68	75	50	40	13	295
2009	49	66	77	51	39	11	293
2010	48	65	76	49	37	13	288
2011	45	62	76	48	37	11	279
2012	46	63	76	48	32	8	273
Total	53	75	79	55	39	20	321

Panel B. Summary statistics of firm characteristics

Var	Firm-year	Mean	10th	25th	50th	75th	90th	Std. Dev
dd1_at	2247	0.02	0	0	0.01	0.02	0.05	0.03
Roll	1835	-0.01	-1.23	-0.68	-0.16	0.5	1.29	1
log asset	2247	9.25	7.85	8.48	9.22	10.02	10.62	1.04
5-year CDS	2247	165.36	23.01	44.28	85.64	189.59	406.38	211.11
dd	2219	2.07	4.19		7.22	10.87	14.39	4.74
mk lev	2247	0.21	0.06	0.11	0.18	0.3	0.4	0.13
mk2bk	2242	1.61	1.04	1.15	1.38	1.84	2.57	0.65
tangibility	2247	0.36	0.07	0.14	0.31	0.55	0.7	0.23
profit	2247	0.13	0.06	0.09	0.12	0.17	0.22	0.06
CP user	2247	0.43	0	0	0	1	1	0.49
Fin segment	2247	0.09	0	0	0	0	0	0.29

Panel C. Summary statistics of log 2-day changes in 5-year CDS spreads and market conditions (%)

Var	N	Mean	10th	25th	50th	75th	90th	Std. Dev.
ΔCDS	224,991	0.08	-4.09	-1.48	0	1.45	4.43	4.07
ΔBaa_AAA	841	0.05	-2.49	-1.12	0	1.19	2.56	2.24
Δon_off	841	0.16	-12.76	-5.26	0	5.64	13.44	11.07
$\Delta T10$	841	-0.14	-3.23	-1.49	-0.21	1.31	3.03	2.85
ΔVIX	841	-0.13	-10.68	-5.6	-0.77	4.6	10.85	8.74

Table 1.2 Two-day Log Changes in CDS and Market Conditions During UMP Events

QE 1_* are five QE 1 announcements. QE 2_* are three QE 2 announcements. $OT*$ stand for Operation Twist. $FG*$ are time-contingent Forward Guidance announcements. QE 1 T_* are three QE 1 exiting announcements. QE 2 T is a QE 2 exiting announcement. All variables, except Δ CDS*, are 2-day **log** changes from day t-1 to day t+1 ($log(X_{t+1}/X_{t-1})$), where t=0 stands for the event date. Δ CDS* is $CDS_{t+1} - CDS_{t-1}$. Baa and AAA are Moody's Baa and AAA index yields. Baa_AAA is the spread between Moody's Baa and AAA index yields. on_off, a market liquidity measure, is the spread between off-the-run and on-the-run 10-year Treasury yields from Citi Yield Book. T10 is the yield on 10-year constant maturity Treasury securities. VIX is the CBOE volatility index, also known as the "fear" index. All values are in percentage points. Numbers in bold are significant at the 99% confidence level.

Event date	**Event**	ΔT_10	ΔBaa	ΔAAA	ΔBaa_AAA	ΔVIX	Δon_off	**# firms**	$\Delta CDS*$	ΔCDS
11/25/2008	QE 1_1	**-11.37**	**-1.76**	**-3.44**	**1.2**	**-16.39**	**26.75**	255	**-7.77**	**-3.2**
12/01/2008	QE 1_2	**-8.92**	**-2.7**	**-5.13**	**1.15**	**13.04**	**13.42**	256	**6.77**	**2.25**
12/16/2008	QE 1_3	**-13.98**	**-4.87**	**-6.85**	**-1.82**	**-13.01**	**17.93**	253	**-8.54**	**-3.25**
01/28/2009	QE 1_4	**10.26**	**2.69**	**5.2**	**-1.68**	**0.89**	**3.43**	246	**-6.65**	**-2.81**
03/18/2009	QE 1_5	**-14.6**	**-2**	**-3.55**	**1.03**	**6.82**	**-2.88**	248	**-6.21**	**-2.58**
08/10/2010	QE 2_1	**-5.02**	**-1.04**	**-1.96**	**2.57**	**13.69**	**-2.22**	269	**7.42**	**3.6**
09/21/2010	QE 2_2	**-6.07**	**-2.3**	**-2.21**	**-2.65**	**4.59**	**9.92**	262	**2.87**	**1.77**
11/03/2010	QE 2_3	**-3.88**	**1.04**	**1.91**	**-2.9**	**-15.25**	**2.38**	266	**-5.81**	**-3.67**
09/21/2011	OT 2011	**-12.56**	**-5.04**	**-5.33**	**-4.09**	**22.98**	**-25.16**	261	**10.74**	**5.09**
06/20/2012	OT 2012	**-0.62**	**-1.4**	**-1.65**	**-0.73**	**8.84**	**-9.19**	250	**1.34**	**0.77**
08/09/2011	FG 2011	**-10.08**	**-1.53**	**-2.82**	**4.12**	**-11.03**	**-5.57**	261	**3.83**	**2.17**
01/25/2012	FG 2012	**-5.95**	**-1.71**	**-1.03**	**-3.62**	**-1.82**	**3.28**	257	**-5.99**	**-3.01**
08/10/2009	QE 1 T_1	**-3.29**	**-0.16**	**-0.38**	**0.77**	**-5.06**	**-31.34**	270	**5.23**	**2.89**
09/21/2009	QE 1 T_2	**-1.75**	**-0.64**	**-0.59**	**-0.89**	**7.79**	**-17.98**	273	**-4.64**	**-2.41**
11/03/2009	QE 1 T_3	**1.98**	**0.93**	**1.7**	**-2.7**	**-12.48**	**-6.38**	272	**-2.31**	**-1.21**
06/22/2011	QE 2 T	**-2.03**	**-0.88**	**-1.22**	**1.3**	**2.25**	**8.83**	258	**2.14**	**1.54**

Table 1.3 Estimated Covariance Risk Exposures

This table shows the covariance of non-overlapping log 2-day changes in market conditions and summary statistics of the β covariances estimated using the following equation:
$\Delta CDS_{it} = \alpha + \beta_1 \Delta Baa\_AAA_t + \beta_2 \Delta on\_off_t + \beta_3 \Delta VIX_t + \beta_4 \Delta T10_t + \eta \Delta mklev_{it} + \lambda \Delta vol_{it} + \varepsilon_{i,t}$
The equation is estimated for each firm each day using an 180-day rolling window. Baa_AAA is the spread between Moody's Baa and AAA index yields. on_off, a market liquidity measure, is the spread between off-the-run and on-the-run 10-year Treasury yields from Citi Yield Book. T10 is the yield on 10-year constant maturity Treasury securities. VIX is the CBOE volatility index, also known as the "fear" index.

Panel A. Correlation Matrix of changes in market conditions (N=841)

	Δ_{Baa_AAA}	Δ_{on_off}	Δ_{VIX}
Δ_{on_off}	0.051		
Δ_{VIX}	0.054	0.046	
Δ_{T10}	-0.095	0.007	-0.345

Panel B. Summary statistics of estimated βs

Var	N	Mean	10th	25th	50th	75th	90th	Std Dev
β_{Baa_AAA}	225,880	0.241	-0.144	0.016	0.202	0.438	0.706	0.353
β_{on_off}	225,880	0.004	-0.078	-0.031	0.004	0.041	0.090	0.073
β_{VIX}	225,880	0.056	-0.066	-0.012	0.039	0.115	0.203	0.111
β_{T10}	225,880	-0.145	-0.613	-0.324	-0.097	0.058	0.246	0.361

Panel C. Correlation Matrix of estimated βs (N=225,880)

	β_{Baa_AAA}	β_{on_off}	β_{VIX}
β_{on_off}	0.045		
β_{VIX}	0.109	-0.113	
β_{T10}	0.021	0.036	0.057

Table 1.4 The Impact of UMP on Risk Premia

The table shows the impact of UMPs on credit risk premia, liquidity risk premia, "fear" premia, and risk-free rate risk premia. The following equation is estimated:

$$\Delta CDS_{i,t} = \alpha + \sum_{k=1,j=1}^{k=4,j=16} \Delta\gamma_{k,j}\beta_{k,i,t} * Event_j + \sum_{j=1}^{16} \theta_j Event_j + \sum_{k=1}^{4} \eta_k \beta_{k,i,t} + \kappa Control_{i,t-1} + \varepsilon_{i,t}$$

where $\beta_{k,i,t}$, k=1, 2, 3, and 4, are the estimated sensitivities of log 2-day changes in CDS spreads to log 2-day changes in Baa-AAA spreads, on-off run 10-year Treasury spreads, VIX, and 10-year Treasury rates in the window [t-180,t-1]; $Event_j$, j=1 to 16, are the QE, FG, and OT announcement dates; $Control_{i,t-1}$ are firms characteristics including maturing long-term debt, firm size, market to book ratio, market leverage ratio, tangibility, and profitability. **To save space, this table only reports the estimations of $\Delta\gamma_{k,j}$.** The equation is estimated using the whole sample and IG and HY subsamples. Columns 1-3 report the estimations of $\Delta\gamma_{Baa\_AAA,j}$; columns 4-6 report the estimations of $\Delta\gamma_{on\_off,j}$; columns 7-9 report the estimations of $\Delta\gamma_{T10,j}$; and columns 10-12 report the estimations of $\Delta\gamma_{VIX,j}$. Firm-fixed effects are controlled. $***p < 0.01, **p < 0.05, *p < 0.1$

		$\Delta\gamma_{Baa\_AAA,j}$ (Expected sign if easing: -)			$\Delta\gamma_{on\_off,j}$ (Expected sign if easing: -)			$\Delta\gamma_{VIX,j}$ (Expected sign if easing: -)			$\Delta\gamma_{T10,j}$ (Expected sign if easing: +)		
		All	IG	HY	All	IG	HY	All	IG	HY	All	IG	HY
	$Event_j$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QE 1	QE 1_1	-0.023***	-0.025***	-0.019	-0.223***	-0.239***	-0.188**	-0.080***	-0.056*	-0.147***	0.067***	0.064***	0.082***
	QE 1_2	0.030***	0.032***	0.028**	-0.067	-0.117*	-0.016	0.036	0.042	0.004	-0.003	0.002	0.002
	QE 1_3	-0.049***	-0.052***	-0.054***	0.004	0.076	-0.082	-0.131***	-0.073***	-0.253***	0.042***	0.036**	0.077**
	QE 1_4	-0.032***	-0.028***	-0.044***	-0.106*	-0.072	-0.134	-0.051***	-0.021	-0.130***	0.027	0.024	0.028
	QE 1_5	-0.028***	-0.024**	-0.029**	0.076	0.014	0.152**	-0.080***	-0.076***	-0.081**	-0.046**	-0.037	-0.058*
QE 2	QE 2_1	0.014	0.015	0.011	0.026	0.074	-0.023	0.120***	0.142***	0.105**	-0.015*	-0.016	-0.014
	QE 2_2	-0.010	-0.009	-0.015	0.069	0.131*	-0.051	0.105***	0.120***	0.100***	-0.009	-0.014	0.011
	QE 2_3	-0.017	-0.036**	0.011	0.004	-0.002	0.021	-0.087***	-0.075***	-0.115***	0.015	0.031*	-0.011
OT	OT 2011	0.031**	0.035**	0.019	0.140**	0.151*	0.160	0.100***	0.121***	0.085	-0.025*	-0.019	-0.046**
	OT 2012	-0.016	-0.020	-0.009	-0.252***	-0.334***	-0.145	0.035	0.016	0.067	-0.035*	-0.046**	-0.021
FG	FG 2011	-0.038***	-0.036**	-0.019	-0.260***	-0.249**	-0.210	-0.038	-0.048	-0.087	0.047***	0.020	0.081***
	FG 2012	-0.043***	-0.032*	-0.056***	-0.051	-0.028	-0.076	-0.091***	-0.088**	-0.085*	0.054***	0.048***	0.067***
Taper	QE 1 T	0.021***	0.032***	0.009	0.012	-0.048	0.069	0.055***	0.053**	0.031	0.002	0.014	0.003
	QE 1 T	0.004	-0.001	0.012	-0.043	-0.068	0.028	-0.044**	-0.035	-0.048	-0.011	-0.019	-0.000
	QE 1 T	-0.003	-0.008	0.002	0.109**	0.092	0.155	0.021	0.029	0.010	-0.000	-0.009	0.012
	QE 2 T	-0.005	0.001	-0.013	-0.053	-0.112	0.034	-0.034	-0.035	-0.010	0.007	0.012	-0.004

Table 1.5 Decomposing Changes in Credit Spreads to Changes in Risk Premia

This table shows the average changes in CDS spreads and the decomposition of these changes during UMP announcements. The decomposition is based on the whole sample. Column 1 reports the average changes in CDS spreads during each announcement. Columns 2-5 display changes attributed to credit risk premia, liquidity risk premia, "fear" premia, and risk-free rate risk premia components, respectively. Each component is calculated as changes in risk premia ($\Delta\gamma$) multiplied by average beta (β) during each announcement. Column 6 presents percentages of changes in average CDS spreads that are explained by changes in all four risk premia. Numbers in bold are significant at the 95% confidence level.

			$\Delta\gamma_{k,j} \times \overline{\beta_k}$				
	$Event_j$	$\overline{\Delta CDS}$	Baa_AAA	on_off	VIX	T 10	% explained
		(1)	(2)	(3)	(4)	(5)	(6)
QE 1	QE 1_1	**-3.2**	**-1.17**	**-1.86**	**-0.37**	**-1.06**	139
	QE 1_2	**2.25**	**1.6**	-0.45	0.25	0.02	63
	QE 1_3	**-3.25**	**-2.36**	0.02	**-0.98**	**-0.28**	110
	QE 1_4	**-2.81**	**-1.59**	**-0.46**	**-0.33**	-0.11	88
	QE 1_5	**-2.58**	**-1.36**	0.34	**-0.39**	**0.08**	51
QE 2	QE 2_1	**3.6**	0.33	-0.01	**1.16**	**0.44**	53
	QE 2_2	**1.77**	-0.3	-0.09	**1.14**	0.11	48
	QE 2_3	**-3.67**	-0.32	0	**-1.07**	-0.13	41
OT	OT 2011	**5.09**	**0.61**	**0.47**	**0.44**	**0.06**	31
	OT 2012	**0.77**	-0.09	**0.3**	0.19	**0.15**	71
FG	FG 2011	**2.17**	**-0.17**	**0.02**	-0.01	**-0.84**	-47
	FG 2012	**-3.01**	**-0.89**	-0.06	**-0.38**	**-0.76**	69
Taper	QE 1 T_1	**2.89**	**0.74**	-0.03	**0.49**	0	41
	QE 1 T_2	**-2.41**	0.13	0.22	**-0.5**	-0.05	8
	QE 1 T_3	**-1.21**	-0.12	**-0.63**	0.11	0	52
	QE 2 T	**1.54**	-0.06	0	0.05	-0.17	-12

Table 1.6 Which Firms Did Each UMP Help More?

This table shows the relationship between changes in CDS spreads during UMP announcements and firm characteristics. The following equation is estimated:

$$\Delta CDS_{i,t} = \alpha + \sum_{k=1,j=1}^{k=8,j=16} \beta_{k,j} Firm\ Characteristics_{k,i,t-1} * Event_j + \sum_{j=1}^{16} \theta_j Event_j + \sum_{k=1}^{8} \eta_k Firm\ Characteristics_{k,i,t-1} + \kappa Control_{i,t-1} + \varepsilon_{i,t}$$

where $Firm\ Characteristics_{k,i,t-1}$, i=1 to 8, include rollover risk measures (dd1_at and Roll), log asset, market-to-book ratio (mk2bk), market leverage ratio (mklev), distance-to-default, whether a firm is a potential user of commercial paper, and whether a firm has a financial business segment. CP user equals 1 if the firm has an S&P short-term debt rating of A-1+, A-1, or A-2. Fin segment equals 1 if the firm reports a business segment with an SIC code between 6000 and 6999 in the recent fiscal year. **To save space, only $\beta_{k,j}$ are reported in this table.** Columns 1-8 report the coefficients of the interaction terms between UMP announcements and eight firm characteristics, respectively. This equation is estimated using ordinary least squares, with firm-fixed effects. Numbers in bold are significant at the 95% confidence level.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$Event_j$	β_{dd1_at}	β_{Roll}	$\beta_{logasset}$	β_{mk2bk}	β_{mklev}	β_{dd}	$\beta_{CP\ user}$	$\beta_{Fin\ seg}$
QE 1	QE 1_1	-0.088	0.001	**-0.009**	0.007	0.008	-0.001	-0.005	-0.004
	QE 1_2	0.062	0.001	0.001	-0.001	-0.033	-0.001	0.007	-0.001
	QE 1_3	-0.117	-0.001	**-0.009**	0.000	0.008	0.000	0.004	-0.010
	QE 1_4	0.112	0.002	**-0.012**	-0.000	0.004	-0.001	0.006	-0.010
	QE 1_5	-0.115	**-0.007**	-0.004	-0.001	-0.000	0.002	0.000	-0.008
QE 2	QE 2_1	-0.072	0.004	**0.006**	0.008	0.003	**-0.003**	0.003	-0.010
	QE 2_2	0.093	0.006	-0.000	-0.001	-0.013	-0.002	0.012	-0.001
	QE 2_3	-0.028	0.002	**-0.011**	-0.011	-0.022	0.001	0.013	0.003
OT	OT 2011	0.072	-0.000	**0.012**	0.002	-0.017	**-0.003**	-0.007	-0.002
	OT 2012	0.082	0.003	-0.000	-0.003	-0.032	-0.000	0.000	-0.000
FG	FG 2011	0.104	0.002	0.001	-0.003	0.011	0.001	-0.009	0.010
	FG 2012	-0.053	0.000	**-0.006**	-0.003	**-0.05**	0.002	-0.004	-0.003
Taper	QE 1 T_1	0.102	0.001	**0.01**	-0.004	**-0.063**	-0.002	-0.003	0.002
	QE 1 T_2	0.072	-0.003	-0.003	0.007	-0.005	0.002	-0.005	0.005
	QE 1 T_3	**0.195**	0.002	-0.004	0.007	0.005	0.002	0.007	-0.000
	QE 2 T	-0.027	-0.006	0.003	-0.000	-0.031	-0.001	-0.003	-0.005

Table 1.7 Summary Statistics of Corporate Bond Maturities Sample

This table shows the summary statistics of bond maturities, macro variables, and firm characteristics. The sample period is between 1990 and 2012. Firm characteristics are collapsed to one observation per firm-month. Data in panel A and B are from Compustat and FISD. Data in panel C are from Flow of Funds.

Panel A. Corporate bond maturity by rating group

Rating Group	firm-month	Mean	Median	Std. Dev.	Min	Max
AAA	317	13.385	10.044	10.748	1.011	99.983
AA- above	773	13.32	10.014	12.601	0.878	100.019
A- above	2944	12.718	10.011	11.348	0.833	100.031
BBB- above	3264	11.892	10.003	10.222	0.608	100.042
BB- above	1401	9.394	9.739	4.291	0.567	60.65
B- above	2675	8.769	9.539	2.179	1.703	30.019
C	389	8.679	8.019	4.272	2	30
NR	560	9.523	9.592	5.446	0.739	57.65

Panel B. Firm Characteristics

Variable	firm-month	Mean	Median	Std. Dev.	Min	Max
age	8385	26.854	25	17.752	2	61
log_at	8385	8.208	8.179	1.535	4.707	11.611
rating	8385	4.68	5	1.593	1	8
mk2bk	8385	1.723	1.452	0.87	0.805	5.67
profit	8385	0.033	0.033	0.023	-0.046	0.101
tangibility	8385	0.404	0.365	0.243	0.031	0.914
asset maturity	8385	6.249	4.52	5.422	0.653	26.593
rndat	8385	0.012	0	0.024	0	0.117
asset vol	8385	0.154	0.086	0.172	0.012	0.891
bklev	8385	0.392	0.358	0.207	0.003	1.116

Panel C. The fraction of preferred-habitat (ph) investors in Treasury and corporate bond markets

Variable	# quarter	Mean	Median	Std. Dev.	Min	Max
Ph in Treasury market	92	0.136	0.132	0.028	0.095	0.186
Ph in Corporate bond market	92	0.385	0.368	0.101	0.255	0.563
Ph in Treasury and Corp bond markets	92	0.267	0.281	0.047	0.183	0.341
Total amount of corporate bond (tn)	92	6.44	5.483	3.755	1.626	12.51
Total Treasury (tn)	92	4.695	3.723	2.326	2.227	11.568

Table 1.8 Corporate Bond Maturities in UMP Periods

This table shows the changes in corporate bond maturities in UMP periods. The dependent variable is the log of corporate bond issuance maturity. Key independent variables are QE 1, QE 2, and FG/OT. QE 1 is a dummy variable that equals 1 if a bond was issued between March 2009 and October 2009. QE 2 is a dummy variable that equals 1 if a bond was issued between November 2010 and June 2011. FG/OT is a dummy variable that equals 1 if a bond was issued between August 2011 and December 2012. Control variables are defined in the appendix. Columns 1 to 4 are estimated using the sample between 1990 and 2012. Columns 5 to 7 are estimated using the sample between 2000 and 2012. Standard errors that are corrected for clustering of observations at the firm level are in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

	Whole sample				After 2000		
	All	IG	HY & NR		All	IG	HY & NR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
QE 1	-0.067**	0.036	-0.120***		-0.053*	0.001	-0.094***
	(0.029)	(0.054)	(0.027)		(0.029)	(0.055)	(0.027)
QE 2	-0.065***	-0.072	-0.042**		-0.032	-0.035	-0.016
	(0.022)	(0.052)	(0.017)		(0.023)	(0.052)	(0.018)
FG/OT	0.013	0.155***	-0.059***		0.052**	0.137***	-0.032*
	(0.024)	(0.046)	(0.020)		(0.024)	(0.043)	(0.019)
recession	-0.133***	-0.139***	-0.082***	-0.140***	-0.106***	-0.143***	-0.059***
	(0.022)	(0.034)	(0.018)	(0.021)	(0.022)	(0.038)	(0.020)
age	-0.000	0.001	-0.001	-0.000	-0.000	0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log asset	-0.013	-0.066***	0.018**	-0.014	0.024**	-0.008	0.034***
	(0.009)	(0.019)	(0.007)	(0.009)	(0.012)	(0.026)	(0.012)
IG dummy	0.104***			0.106***	0.077**		
	(0.030)			(0.031)	(0.035)		
stock return	0.089***	0.243***	0.036***	0.092***	0.059***	0.062	0.035**
	(0.015)	(0.050)	(0.011)	(0.015)	(0.015)	(0.049)	(0.014)
rating	-0.042***	-0.078***	-0.021**	-0.043***	-0.014	0.022	-0.029**
	(0.011)	(0.026)	(0.009)	(0.011)	(0.014)	(0.036)	(0.013)
rating square	-0.000	-0.010*	0.001	0.000	-0.002**	-0.007	-0.000
	(0.001)	(0.005)	(0.001)	(0.001)	(0.001)	(0.005)	(0.001)
mk2bk	-0.011	-0.064**	0.033***	-0.010	-0.009	-0.040	0.054***
	(0.015)	(0.029)	(0.009)	(0.015)	(0.017)	(0.034)	(0.017)
profit	0.024	-0.242	0.674**	0.010	1.096**	1.509	0.951**
	(0.375)	(0.786)	(0.288)	(0.373)	(0.460)	(1.068)	(0.436)
asset maturity	0.006***	0.004	0.004***	0.006***	0.007**	0.009	0.004*
	(0.002)	(0.005)	(0.002)	(0.002)	(0.003)	(0.006)	(0.002)
rndat	-0.160	0.522	0.190	-0.138	-1.150	-1.140	-0.214
	(0.642)	(1.231)	(0.622)	(0.642)	(0.741)	(1.411)	(0.854)
asset volatility	0.079*	0.059	0.096***	0.087**	0.018	-0.089	0.042
	(0.042)	(0.139)	(0.031)	(0.042)	(0.062)	(0.189)	(0.052)
bklev	-0.114***	-0.193	-0.149***	-0.111**	-0.162***	-0.027	-0.213***
	(0.044)	(0.170)	(0.033)	(0.044)	(0.051)	(0.172)	(0.046)
Constant	2.515***	3.313***	2.112***	2.521***	2.029***	2.228***	2.003***
	(0.109)	(0.236)	(0.088)	(0.107)	(0.138)	(0.316)	(0.142)
4-digit SIC-fixed	Y	Y	Y	Y	Y	Y	Y
Observations	8,016	4,040	3,976	8,016	4,648	2,052	2,596
R-squared	0.153	0.170	0.234	0.152	0.190	0.233	0.255

Table 1.9 Gap-filling and Market-timing

This table shows the estimations of the impact of Treasury maturities, preferred-habitat investors, and term spreads on corporate bond maturities. The dependent variable is the log of corporate bond issuance maturity. In columns 1-4, Treasury maturity is the log of the average outstanding Treasury maturities, and preferred-habitat is the fraction of preferred-habitat investors in the Treasury and corporate bond markets. In columns 5-7, Treasury maturity and preferred-habitat investors are orthogonalized to the variable "time trend". All regressions include 4-digit SIC-fixed effects. Standard errors that are corrected for clustering of observations at the firm level are in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

					Using orthogonalized key variables		
	All	All	IG	HY	All	IG	HY
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treasury maturity	-0.442***	1.832***	2.383**	1.367***	0.254**	0.494**	0.053
	(0.096)	(0.593)	(0.964)	(0.473)	(0.123)	(0.233)	(0.099)
Treasury maturity		-5.767**	-6.718*	-4.971***	-47.725***	-58.026***	-40.483***
*preferred-habitat		(2.282)	(3.752)	(1.771)	(10.616)	(17.061)	(8.836)
preferred-habitat		-0.573	-6.279	6.222**	-7.445***	-13.822***	-0.270
		(4.054)	(6.718)	(3.091)	(1.490)	(2.560)	(1.116)
Term spread	-0.014*	-0.056***	-0.092***	-0.017**	-0.050***	-0.086***	-0.011
	(0.008)	(0.008)	(0.014)	(0.007)	(0.008)	(0.014)	(0.007)
Time trend	-0.003***	-0.008***	-0.012***	-0.003***	-0.002***	-0.002***	-0.001***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)
10-year Treasury rate	-0.065***	-0.063***	-0.107***	-0.013	-0.054***	-0.100***	-0.003
	(0.014)	(0.014)	(0.023)	(0.010)	(0.014)	(0.023)	(0.011)
recession	-0.118***	-0.093***	-0.117***	-0.060***	-0.066***	-0.093**	-0.029
	(0.021)	(0.021)	(0.034)	(0.017)	(0.024)	(0.037)	(0.018)
age	0.000	-0.000	0.002	-0.000	-0.000	0.002	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log asset	0.005	0.008	-0.041*	0.032***	0.008	-0.043**	0.033***
	(0.009)	(0.009)	(0.021)	(0.007)	(0.009)	(0.021)	(0.007)
IG dummy	0.088***	0.081***			0.082***		
	(0.030)	(0.030)			(0.030)		
stock return	0.105***	0.095***	0.182***	0.050***	0.089***	0.172***	0.045***
	(0.015)	(0.015)	(0.047)	(0.010)	(0.015)	(0.048)	(0.011)
rating	-0.027**	-0.026**	-0.043	-0.018**	-0.025**	-0.044	-0.018**
	(0.010)	(0.010)	(0.029)	(0.009)	(0.010)	(0.028)	(0.009)
rating square	0.000	-0.001	-0.009	0.001	-0.001	-0.010**	0.001
	(0.001)	(0.001)	(0.005)	(0.001)	(0.001)	(0.005)	(0.001)
mk2bk	-0.004	0.005	-0.017	0.032***	0.005	-0.017	0.033***
	(0.014)	(0.014)	(0.026)	(0.009)	(0.014)	(0.026)	(0.009)
profit	0.095	-0.027	-0.397	0.684**	-0.037	-0.403	0.676**
	(0.372)	(0.373)	(0.779)	(0.287)	(0.373)	(0.780)	(0.288)
asset maturity	0.006***	0.005**	0.003	0.003**	0.005**	0.003	0.003**
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.005)	(0.002)
rndat	-0.682	-0.713	-0.099	0.068	-0.683	-0.066	0.096
	(0.637)	(0.635)	(1.231)	(0.610)	(0.642)	(1.257)	(0.611)
asset volatility	0.046	0.070	0.139	0.043	0.074*	0.143	0.048
	(0.044)	(0.045)	(0.137)	(0.033)	(0.045)	(0.136)	(0.033)
bklev	-0.129***	-0.117***	-0.088	-0.153***	-0.116***	-0.086	-0.153***
	(0.042)	(0.041)	(0.160)	(0.032)	(0.041)	(0.158)	(0.032)
Constant	3.839***	3.546***	6.059***	0.798	2.890***	3.813***	2.216***
	(0.276)	(1.044)	(1.712)	(0.799)	(0.151)	(0.300)	(0.116)
4-digit SIC-fixed	Y	Y	Y	Y	Y	Y	Y
Observations	8,016	8,016	4,040	3,976	8,016	4,040	3,976
R-squared	0.167	0.177	0.197	0.263	0.179	0.199	0.267

Table 1.10 Heckman Selection Model: The Impact of Preferred-habitat Investors

This table shows estimations of corporate bond maturities using Heckman Selection models. For each specification, the determinants of whether a firm issues a bond are estimated in the first stage. The determinants of corporate bond maturities are estimated in the second stage. Issue bond is a dummy variable that equals 1 if a firm issues a bond in a month. Standard errors that are corrected for clustering of observations at the firm level are in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

	(1)		(2)		(3)	
	Issue bond	bond maturity	Issue bond	bond maturity	Issue bond	bond maturity
Treasury maturity	-0.024	0.086	-0.044		-0.116**	1.046***
	(0.052)	(0.065)	(0.043)		(0.052)	(0.342)
Treasury maturity						-2.936**
*preferred-habitat						(1.159)
preferred-habitat	1.638***		2.700***	-8.029***	3.001***	-4.460**
	(0.418)		(0.423)	(1.049)	(0.448)	(1.959)
Time trend		-0.001**		-0.006***		-0.007***
		(0.000)		(0.001)		(0.001)
Term spread	0.066***	-0.063***	0.069***	-0.086***	0.074***	-0.097***
	(0.007)	(0.009)	(0.007)	(0.009)	(0.007)	(0.009)
10-year Treasury rate	0.029***	-0.039***	0.006	-0.041***	0.009	-0.031**
	(0.009)	(0.014)	(0.009)	(0.014)	(0.009)	(0.014)
recession	-0.094***	-0.072***	-0.086***	-0.078***	-0.088***	-0.058**
	(0.020)	(0.025)	(0.021)	(0.025)	(0.021)	(0.024)
age	0.007***	-0.004***	0.007***	-0.005***	0.007***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
log asset	0.248***	-0.140***	0.249***	-0.137***	0.247***	-0.126***
	(0.012)	(0.017)	(0.012)	(0.017)	(0.012)	(0.017)
IG dummy	-0.236***	0.331***	-0.239***	0.316***	-0.101**	
	(0.054)	(0.053)	(0.054)	(0.052)	(0.043)	
rating	0.237***	-0.250***	0.242***	-0.241***	0.319***	-0.377***
	(0.092)	(0.083)	(0.093)	(0.082)	(0.093)	(0.076)
rating square	-0.032***	0.032***	-0.033***	0.030***	-0.037***	0.036***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
mk2bk	0.010**	0.013	0.010**	0.023**	0.010**	0.023**
	(0.004)	(0.011)	(0.004)	(0.011)	(0.004)	(0.011)
profit	0.052	0.928***	0.057	0.799***	0.066	0.729***
	(0.169)	(0.279)	(0.168)	(0.278)	(0.168)	(0.278)
asset maturity	-0.000	0.006***	-0.000	0.005**	-0.000	0.005**
	(0.000)	(0.002)	(0.000)	(0.002)	(0.000)	(0.002)
rnd	-2.244***	2.520***	-2.248***	2.301***	-2.189***	2.117***
	(0.381)	(0.731)	(0.382)	(0.750)	(0.381)	(0.732)
asset volatility	0.775***	-0.615***	0.768***	-0.578***	0.767***	-0.558***
	(0.054)	(0.067)	(0.054)	(0.066)	(0.054)	(0.067)
bklev	0.502***	-0.577***	0.499***	-0.546***	0.514***	-0.572***
	(0.051)	(0.060)	(0.051)	(0.059)	(0.051)	(0.061)
long-term debt	0.412***		0.421***		0.431***	
	(0.059)		(0.059)		(0.060)	
Constant	-5.085***	5.773***	-5.251***	8.867***	-5.511***	7.965***
	(0.339)	(0.480)	(0.344)	(0.570)	(0.342)	(0.714)
4-digit SIC-fixed	N	Y	N	Y	N	Y
Observations	213,326	213,326	213,326	213,326	213,326	213,326

Chapter 2

Margin-based asset pricing and the determinants of the CDS basis

2.1 Introduction

Since Credit Default Swap (CDS) contracts and their reference cash bonds bear similar credit risk, the CDS basis, which is the difference between the CDS spread and the bond implied credit spread, should be close to zero according to the Law of One Price. In fact, it was kept close to zero before the 2007-2009 financial crisis due to active basis arbitrages (Hull et al. [2004]; Blanco et al. [2005]). However, as shown in Figure 2.6, it became significantly and persistently negative during the recent financial crisis, indicating a long-lasting arbitrage opportunity. This phenomenon contradicts the fact that the non-zero basis is the target of sophisticated traders in investment banks and hedge funds. Consequently, the basis anomaly draws attention from both practitioners and academic researchers (see Arora et al. [2011]; Bai and Collin-Dufresne [2010]; Bhanot and Guo [2011]; Garleanu and Pedersen [2011]; Gorton [2009]).

Our paper on the determinants of the CDS basis is closely related to the margin-based asset pricing theories that attribute the market anomalies to margin requirements and investors' funding status (Brunnermeier and Pedersen [2009]; Garleanu and Pedersen [2011]). Consistent with the practice, the theories assume that risk-tolerant investors (arbitragers) rely on collateralized borrowing to fund their trading. Since the collateral (margin) must be equity capital or uncollateralized loans, risk-tolerant investors' the borrowing capacity is subject to the collateral they can use. When investors cannot borrow freely, the required return of an asset should compensate for its margin requirement in addition to the risk-adjusted return. Therefore, all things being equal, the required return of an asset that has a higher margin requirement should be higher.

The margin-based asset pricing theories suggest that the long-lasting negative CDS basis in the financial crisis could be due to different margin requirements of CDS and cash bond trading rather than arbitrage opportunities. For example, the collateral required on selling the CDS contract is about 5% of the notional amount, while the collateral required on the leverage buying of investment-grade (high-yield) corporate bonds is about 20% (50%) (Garleanu and Pedersen [2011])[1]. For negative basis trading, arbitragers need to buy CDS contracts and cash bonds at the same time, generating net margin outflow. When the funding constraint is binding, the margin capital becomes scarce. Therefore, the required return increases with the required margin capital. In other words, the CDS basis should not be zero.

The primary purpose of this paper is to test the implications of margin-based asset pricing theories using single-name CDS data. These theories have both time series and cross-sectional implications. The time series implication is that the CDS basis decreases more negatively as the marginal required return of margin capital increases. The cross-sectional implication is that the CDS basis is proportional to the amount of margin required. In the time series analysis, we proxy the required return of margin capital by the shadow cost, credit risk premium, and bond market illiquidity. In particular, we use Libor-OIS spreads and Repo rates to poxy funding cost (Bai and Collin-Dufresne [2010]), daily innovations in BAA-AAA spread to proxy the credit risk premium, and daily bond market Amihud innovations (Lin et al. [2011]) to proxy the market illiquidity in the fixed income market. Using daily single-name CDS data,

[1]For trades relying on the repurchase agreement (repo) financing, the Repo haircut for corporate bonds collateral increased from 3%-4% in 2007 to 5%-7% in 2010. In the crisis, the Repo market using corporate debt as collateral almost disappeared (Krishnamurthy et al. [2012]).

our time series results confirm the margin-based asset pricing theories in that the CDS basis decreases more negatively as the funding costs, credit risk premium, and market illiquidity increase.

The test of the cross-sectional implications is less straightforward, since the margin requirements on individual contracts are opaque. However, the margin requirements can be proxied by the sensitivity of CDS basis to the marginal return on capital. Intuitively, when the marginal return of capital changes, the required return of trading that requires a larger amount of margin capital will change more aggressively. Therefore, the cross-sectional implication of the margin-based asset pricing theories is that the CDS basis is more negative if the basis trading is more sensitive to shadow cost, credit risk premium, and market liquidity. We examine the relationship using daily Fama-MacBeth style cross-sectional regressions. We find that the sensitivities of the CDS basis to funding costs, credit risk premium, and market liquidity are priced in the CDS basis. The pricing effect becomes more prominent with economic downturns. In particular, one standard deviation change in the sensitivity of CDS basis to Libor-OIS spread, BAA-AAA spread, and market Amihud in post-Lehman/AIG bankruptcy period is associated with 40 bps, 16 bps, and 12 bps changes in CDS basis, respectively. The economic effects are nontrivial considering that one standard deviation of CDS basis is 185 bps in this period.

Next, we run a horse racing of the non-mutually exclusive determinants in the literature. In particular, we examine the individual liquidity, counterparty risk, short-constraint, and cheapest-to-delivery options. Bonds with higher individual liquidity are relatively more expensive than their CDS contracts, leading to a higher CDS basis (Bhanot and Guo [2011]; Nashikkar et al. [2011]). Counterparty risk reflects the concern that the CDS sellers may default before the reference entity defaults. The higher the counterparty risk, the lower the CDS spread, and the lower the CDS basis (Arora et al. [2011]; Bai and Collin-Dufresne [2010]). Finally, the short-constraint and cheapest-to-delivery options drive the CDS basis to the positive domain (Hull et al. [2004]; Blanco et al. [2005]; Nashikkar et al. [2011]). To the best of our knowledge, none of the existing papers have tested all the determinants in a unified framework. The coefficients of all the determinants have the expected sign, except counterparty risk in the time series analysis. Our results show that the cross-sectional R square using the explanatory variables suggested by the margin-based asset pricing theories alone is 17.5%. Adding other determinants in the literature raises the R square to 51.2%.

In sum, we confirm the important cross-sectional implications of the margin-based asset pricing theories. Furthermore, our findings suggest that the margin requirement matters both statistically and economically even in normal time, when the funding constraint is not theoretically binding. Therefore, the margin requirement is an important element in asset pricing.

The rest of the paper is organized as follows. Section 2 discusses the CDS, the basis trading, and the potential determinants of the CDS basis. Section 3 describes the data and variable constructions. Section 4 displays the empirical results using time series analysis. Section 5 shows the results using Fama-MacBeth cross-sectional regressions. Section 6 concludes the paper.

2.2 CDS, Basis, and Determinants

CDS and basis trading

Corporate bond holders are subject to interest rate risks, funding risks, and default risks. Default risks, assuming non-defaultable CDS protection sellers, can be hedged by buying CDS protections on bonds. CDS is like an insurance contract wherein cash flows are contingent on credit events of its reference entity[2]. CDS buyers pay a

[2]According to the International Swaps and Derivatives Association (ISDA) definition, credit events include bankruptcy, failure to pay, restructuring, obligation default, obligation acceleration,

fixed amount of money, called the CDS premium, to the CDS seller quarterly until the maturity of the contract or the occurrence of credit events, whichever comes first. This stream of CDS buyers' cash outflows is called the premium leg of CDS payment. CDS sellers, if no credit event occurs, do not need to pay anything to CDS buyers but post collateral to reduce the counterparty risk (Arora et al. [2011]). In case of credit events, there are two kinds of settlements: physical and cash settlements. In physical settlements, CDS sellers pay the CDS buyers the par value of reference assets and receive the reference assets from the CDS buyers. In cash settlements, CDS sellers pay the CDS buyers the difference between par value and market value of a debt obligation of the reference entity. This stream of CDS sellers' cash outflow is called the contingent leg of CDS payment. In equilibrium, the CDS spread, the market price of CDS contract, is at a level that the present value of the premium leg equals that of the contingent leg.

Since CDS contracts and cash bonds carry the same credit risk of a reference entity, the default probability implied by CDS spreads and bond prices should be the same. In other words, the real CDS spread and the CDS spread extrapolated using bond market price implied default intensity (bond-implied CDS spread) should be the same. Hence, the CDS basis, which is the difference between CDS spread and bond-implied CDS spread, should be zero in a frictionless world, because of the Law of One Price. Otherwise, arbitragers can make riskless profit from trading bonds and CDS contracts. For example, if the CDS basis is positive, arbitragers can sell the CDS contract and sell short the bond to earn riskless abnormal profits. Contrarily, if the CDS basis is negative, arbitragers can buy cash bonds and buy corresponding CDS contracts, locking in riskless abnormal profits. Such trades are known as basis trading.

The active basis trading kept the CDS basis close to zero before the 2007-2009

and repudiation/moratorium.

crisis. Because of short selling constraints and cheapest-to-delivery options[3], the CDS basis was usually slightly positive (Blanco et al. [2005]). However, the CDS basis became significantly negative and persistent during the financial crisis, forming one of the violations of Law of One Price during the period (Bai and Collin-Dufresne [2010]). These violations draw researchers' attentions to the limits of arbitrage, for example: the lack of bond market liquidity, slow moving capital, funding risk, and counterparty risk (see Bhanot and Guo [2011]; Nashikkar et al. [2011]; Mitchell and Pulvino [2011]; Arora et al. [2011]; Bai and Collin-Dufresne [2010]). Another strand of literature, to which this paper is closely related, attributes the violations to the funding availability in the market because of the margin requirement involved in the trades (Brunnermeier and Pedersen [2009]; Garleanu and Pedersen [2011]).

The purpose of this paper is twofold. First, we explore the effect of the potential determinants implied by the margin based theories. Second, we run a horse race on all the above mentioned determinants, and show the relative importance of each factor in different market conditions.

Margin-based asset pricing and determinants of the CDS basis

In the practice, the CDS basis trading requires capital. To make profit from the negative CDS basis, a trader (e.g., a dealer, a hedge fund, or an investment bank) will buy cash bond and the corresponding CDS contract to protect the position. The trader can either fund the long position in cash bond through leverage buying, which requires margin, or through repurchase agreement, which has haircut. The long-position in the CDS contract will receive margin from the counterparty. Since

[3]For example, the CDS contracts with credit event "M" allow the delivery of bonds with maturity within 30 months of the contractual maturity, giving protection buyers the option to choose which bond to deliver.

the value of a CDS contract is zero by design, the margin requirement is only to mitigate the counterparty risk. Therefore, the margin received in a CDS contract is much less than that required by the leverage buying of cash bond. In normal time, the Repo haircut is low. However, in the crisis, the Repo market was in a run and the Repo transactions using corporate bond as collateral almost disappeared (Gorton and Metrick [2011]; Krishnamurthy et al. [2012]). That is to say, negative CDS trading requires margin capital. Positive basis trading also requires margin capital in that both short selling of cash bonds and selling CDS contracts require margin. The margin should be from investors' equity capital or uncollateralized loans.

The margin requirement depends on both securities' characteristics and market conditions (Brunnermeier and Pedersen [2009]). On one hand, margin requirements on riskier and more illiquid securities are higher to control for value at risk. On the other hand, margin requirements increase with market uncertainty, because investors cannot determine the fundamental value of financial assets. The increased margin requirement constrains investors' funding capacity, which further decreases market liquidity. When market liquidity decreases, the collateral loses value, and therefore margin requirements increase. As such, funding illiquidity and market illiquidity form spirals. When investors' funding constraint is binding, margin capital becomes valuable, and investors pick the projects that have the highest return, leaving low-return text-book arbitrage opportunities outstanding.

Adding a funding constraint to the classic CCAPM, Garleanu and Pedersen [2011] model the required return of securities with margin requirements. The required return is the covariance risk premium plus the production of margin premium multiplied by margin. Therefore, the required returns on two assets that give similar cash flows can be different if the two assets have different margin requirements. The CDS basis is a good example of such asset pairs in that CDS contract and cash bonds bear the same credit risk and differ in margin requirements. As such, the required return on

CDS basis is positive because of margin requirements, and investors only trade on the CDS basis that yields a return higher than the required return.

The margin-based asset pricing model suggests that CDS basis, the return of basis trading, should increase with margin premium and margin requirements, where margin premium increases with funding cost and average investors' risk aversion. The shadow cost is also referred to as funding illiquidity in the literature. Using the difference between Libor and short-term U.S. government debt spread (TED) and the tightness of credit standards reported in Federal Reserve Board's survey "Senior Loan Officer Opinion Survey on Bank Lending Practices" as proxies of funding liquidity, Garleanu and Pedersen [2011] find that the basis on CDX widens with the increase in credit standards tightness in a monthly time series analysis. Using Libor-OIS spread and the difference between Repo rates on general collateral and Treasury rates as proxies for funding liquidity, Bai and Collin-Dufresne [2010] find that the CDS basis decreases more negatively with the increase in funding liquidity risk in time series analysis. However, they find mixed results in cross-sectional regressions.

In this paper, we propose another measure for funding availability of corporate bond market: the corporate bond market liquidity. We use market liquidity as a proxy for funding liquidity of corporate bond investors for three reasons. First, according to Brunnermeier and Pedersen [2009] proposition 1, any asset's market illiquidity (to distinguish from the whole market liquidity, we will call it individual liquidity hereafter), measured by the deviation of market price from its fundamental value, equals the product of its margin requirements and the investors' shadow cost of capital in equilibrium. This proposition immediately implies that market liquidity of corporate bonds captures both the average margin requirement and the shadow cost of investors' capital, therefore capturing funding liquidity more comprehensively. Secondly, capital has a slow moving character in terms of the searching cost and time of raising capital (Duffie [2010]). Putting it differently, the market segmentation does exist to some extent, and the market's general features such as Libor-OIS/TED spread or overall credit standard cannot fully capture the corporate bond market funding liquidity. Contrarily, market liquidity, by the nature of its construction process, quantifies funding liquidity of corporate bond investors more precisely. Thirdly, market liquidity gives information beyond that which is given by individual liquidity, credit rating, and other bond characteristics in studying bond yields (Lin et al. [2011]; Helwege et al. [2014]). Therefore, market liquidity is not simply measuring the average of individual liquidities.

In fact, our cross-sectional regression results show that the risk premia on Libor-OIS/Repo is not significant in early crisis (late crisis). The result on Libor-OIS is consistent with the anecdotal evidence that Libor rate is subject to manipulation that it sometimes cannot reflect the real uncollaterized interest rate; and the result on Repo is consistent with the empirical findings in the literature that Repo market for corporate bond almost disappeared in late crisis. Contrarily, the risk premium on market liquidity measured by bond market Amihud is always positive, indicating that market liquidity describes funding liquidity more reliably.

Other determinants

Individual liquidity

There is a large body of literature on individual liquidity as a determinant of the non-default component of bond yields (see Longstaff et al. [2005]; Chen et al. [2007]; Covitz and Downing [2007]; Mahanti et al. [2008]; Bhanot and Guo [2011]; Dick-Nielsen et al. [2012]; Helwege et al. [2014]; Lin et al. [2011]; Nashikkar et al. [2011]). Since a detailed review of the liquidity literature is beyond the scope of this paper, we only briefly discuss the working mechanism of individual liquidity. On one hand, individual liquidity measures the ease of trades; hence, investors require a higher liquidity premium on holding bonds with lower liquidity. On the other hand, the margin requirements on illiquid bonds are higher, resulting in higher margin-based liquidity premium (Brunnermeier and Pedersen [2009]; Garleanu and Pedersen [2011]). The CDS basis is naturally affected by individual liquidity (Nashikkar et al. [2011]; Bhanot and Guo [2011]).

We also find that the individual liquidity measures are significant and important after controlling for funding liquidity and credit risk premium, as well as collateral requirements.

Counterparty risk

The collapses of Bears Sterns, Lehman Brothers, and AIG highlight the counterparty risk in CDS trades. Counterparty risk means that the CDS protection buyers are subject to the risk that the CDS sellers will default before the default of the reference entity, which renders the CDS contract worthless. In such sense, the spread of the CDS protections sold by dealers with higher default risk should be lower to compensate for the counterparty risk. Using credit spreads of major CDS dealers as a proxy for counterparty risk, Arora et al. [2011] find that this is true statistically but not economically, partially because of the collateral requirement in CDS trading. Using the stock returns of major dealers as a proxy for counterparty risk, Bai and Collin-Dufresne [2010] find that the CDS basis increases with primary dealers' stock returns in time series analysis, which is consistent with the predication of the counterparty risk theory. We control for counterparty risk using the primary dealers' stock return following Bai and Collin-Dufresne [2010].

2.3 Data and Variables

This section describes the data, sample construction, and variables.

Credit default swap data

The sample period is between November 2006 and April 2009, which covers normal time, early subprime crisis, and post Lehman/AIG crisis periods. The daily credit default swap (CDS) spreads are obtained from GFI, which is a major inter-dealer broker (IDB) that specializes in the trading of credit derivatives. GFI quote data consists only of real market bid/ask price and trade information, reflecting accurate market sentiment. Most of the single name CDS contracts on corporate bonds in this data are written on senior debt, with the rest on subordinated debt. The credit events are classified as Restructuring, Modified, Modified-modified, and No restructuring[4]. The credit event "Modified" accounts for about 70% of the quotes in the data. The maturity of single name CDS contracts are 1, 2, 3, 4, 5,10, and a few uneven years, 81% of which are 5 years. GFI data has been used by Hull et al. [2004], Saita [2006],Nashikkar and Subrahmanyam [2006], Fulop and Lescourret [2007], and Subrahmanyam et al. [2009] among others[5].

Since neither CDS nor bond markets are very liquid, we follow Bai and Collin-Dufresne [2010] and use CDS curve data which is constructed by GFI based on real quotes and trades. Admittedly, the curve data may not respond fast enough to the real changes in the market. We relieve this concern by only keeping the curve data on the most liquid CDS contracts, 5 years contracts. As the cheapest-to-delivery option biased the CDS basis toward a positive domain (Blanco et al. [2005]), we only keep CDS data with the credit event "Modified" allowing only the delivery of bonds

[4]According to 1999 ISDA credit derivatives definition, "Restructuring" accounts restructuring of corporate debt as a credit event, and any bond of maturity up to 30 years is deliverable. In 2001, ISDA modified the restructuring clause as "Modified restructuring", which still counted restructuring (except restructuring of bilateral loans) as credit events, but limited the deliverable bonds to those with a maturity of 30 months or less after the termination date of the CDS contract. The Modified-modified clause is introduced in 2003 that allows for the delivery of obligations with a maturity of 60 months or less. No restructuring does not account restructuring as a trigger event. For detailed discussions, please see Packer et al. [2005].

[5]See Mayordomo et al. [2010] for detailed comparison of different CDS datasets.

with a maturity less than 30 months upon the credit event. The contracts written on subordinated debt are also dropped from the sample. Finally, we restrict the CDS contracts to those written on US corporations and denoted in US dollars.

Bond data

The bond data is obtained from two different sources. The transaction price information is from TRACE. The transaction data is further merged with the Fixed Investment Securities Database (FISD) to obtain bond characteristic information, such as issue dates, maturity dates, issue amount, and rating information. TRACE was officially launched in 2002 by the Financial Industry Regulatory Authority (FINRA), which replaced NASD. TRACE gradually increases its coverage of the bond market over time. By July 1, 2005, FINRA requires all its members to report their trades within 15 minutes of the transaction. Trace provide trading information on 100 percent of OTC activity representing over 99 percent of total U.S. corporate bond market activity in over 30,000 securities. The only trades not covered by TRACE are trades on NYSE, which are mainly small retail trades.

To eliminate the noise introduced by retailers, we exclude the trades with trading amount less than $100,000. Since the CDS contracts are written on senior debts, we limit the bond data to those on senior unsecured bonds. Further, to keep the observations comparable, we follow the tradition and focus only on fixed coupon rate straight bonds with semi-annual coupon payments. The information contained in TRACE includes transaction dates and transaction price (clean price or price with commissions). We exclude transactions for which prices are mixed with commissions. The transactions which are canceled or revised by other submissions are dropped from the sample. To constraint the liquidity noise, we exclude the bonds with time to maturity less than one year.

After matching CDS data with bond trading data, we only keep one bond with time to maturity closest to 5 years for each firm each day. The cleansing process result in 242 unique referenced firms and 711 bonds during November 2006 and April 2009.

CDS basis

CDS basis is defined as the difference between CDS premium and bond-implied credit risk premium. Following studies such as Elizalde et al. [2009], Bai and Collin-Dufresne [2010], and Nashikkar et al. [2011], I use par-equivalent CDS spread (PECDS hereafter) method to calculate the bond-implied CDS premium. The CDS basis can be expressed as follows:

$$Basis_{i,\tau} = CDS_{i,\tau} - PECDS_{i,\tau} \tag{2.1}$$

where i stands for firm i, and τ stands for maturity. Some papers also use Z-Spread directly as a proxy for bond-implied CDS premium. We prefer the PECDS method, developed by JP Morgan, to Z-Spread in that the former allows default before maturity, and adjusts for non-par traded bonds[6], therefore giving more accurate estimations.

We first use numerical methods to get bond-implied default intensity which equates the present value of future bond cash flows to the market price. The relationship can be expressed using the following equation:

$$\begin{aligned} MV_{bond} = & \sum_{i=1}^{n} Z(t_i) S_{bond}(t_i) C_{bond} dt + R \sum_{i=1}^{n} Z(\frac{t_i + t_{i-1}}{2}) \left[S_{bond}(t_{i-1}) - S_{bond}(t_i) \right] \\ & + Z(t_n) S_{bond}(t_n) Par \end{aligned} \tag{2.2}$$

where MV_{bond} is the market price of bond, $Z(t_i)$ is the discount factor, $S_{bond}(t) = exp(-\lambda\tau)$ is the survival probability with constant default intensity λ, C_{bond} is the coupon rate of the reference bond, R is the recovery rate, and par is normalized to 1. The coupons are paid semiannually, and n counts the times of coupon payment until

[6]For details of the comparison, please refer to Elizalde et al. [2009] and Nashikkar et al. [2011].

maturity. We then use iteration method and get the bond-implied default intensity λ. Discount factor here is constructed using USD-Libor swap rate because Blanco et al. [2005] find that CDS spreads are quite close to bond yield speeds when using swap rate as risk free rate. Indeed, as noticed by Nashikkar et al. [2011], the Libor swap itself contains credit risk of banks, and therefore underestimating the PECDS. The effect will bias the coefficients on credit risk related variables toward insignificant.

We then calculate par equivalent CDS spread with the bond-implied default intensity using the following equation:

$$PECDS = \frac{(1-R)\sum_{i=1}^{n} Z(\frac{t_i+t_{i-1}}{2})[S_{bond}(t_{i-1})-S_{bond}(t_i)]}{\sum_{i=1}^{n}[Z(t_i)S_{bond}(t_i)\times dt + Z(\frac{t_i+t_{i-1}}{2})[S_{bond}(t_{i-1})-S_{bond}(t_i)]\times dt/2]} \times 4 \tag{2.3}$$

where the nominator represents the present value of the default leg, and the denominator is the value of premium leg if CDS spread is 1 per quarter. As in practice, we allow the quarterly payment of CDS spread, and ask for accrued premium payment when credit events occur.

Subtracting the bond-implied CDS spread we get in equation 2.3 from the real CDS spread, we get the CDS basis. If the CDS basis is less than 0, then the bond yield is higher than the risk-neutral required return.

Variables

A. Individual bond liquidity

Liquidity of individual bond is proxied by Amihud measure (Amihud [2002]), and Roll measure (Roll [1984]). Based on the market depth concept introduced by Kyle [1985], Amihud measure estimates the price impact of trades, while Roll measure gives an effective bid-ask spread (Roll [1984]). An increase in Amihud measure or the Roll measure indicates higher bond illiquidity. We follow Lin et al. [2011] to construct both individual and market liquidity.

To construct market Amihud measure, we first calculate returns of all trades in cleaned TRACE data as $r_\tau = \frac{(P_\tau + AI_\tau) - (P_{\tau-1} + AI_{\tau-1} + C_t)}{P_{\tau-1} + AI_{\tau-1}}$, where P_τ is the transaction price, and AI_τ is the accrued interest. C_τ equals semi-annual coupon payment immediately after the coupon payment date, and 0 otherwise. Then we calculate daily Amihud (Amihud [2002] for each bond in TRACE data using the following equation

$$Amihud_{it} = \frac{1}{N} \sum_{j=1}^{N} \frac{\mid r_{ij,t} \mid}{Vol_{ij,t}} \tag{2.4}$$

where N is total number of trades per day, $r_{ij,t}$ is the return on the j_{th} trading in day t for firm i, and $Vol_{ij,t}$ is the trading volume in dollars associated with trade j. Since the Amihud measures are too small in value, we time Amihud measure by 100 million.

Daily Roll measure (Roll [1984]) for a bond in day t is defined as

$$Roll_{it} = 2\sqrt{-Cov(\Delta P_{it}, \Delta P_{it-1})} \tag{2.5}$$

where P_{it} is weighted average daily trading price for bond i. The covariance is calculated using a 60 day rolling window, and requires at least 8 daily observations in the window (Friewald et al. [2012]).

B. Funding liquidity

As discussed in section 2, funding liquidity contains two aspects, the funding cost and funding availability. We use the following proxies.

- Libor-OIS spread. This variable is constructed by subtracting overnight index swap rates from Libor rates. The spread reflects a liquidity premium in that higher Libor-OIS spread indicating higher shadow cost of capital and lower liquidity in money market. However, this spread also contains credit risk component, as higher spread implying a higher concern on the default probability of banks (Bai and Collin-Dufresne [2010]; Gorton and Metrick [2011]). Moreover, it may also subject to manipulation that it sometimes cannot reflect the real uncollaterized interest rate.

- Repo. This variable is constructed by subtracting Repo rate collateralized by government securities from that by mortgage backed securities. Repo here both reflects the scarcity of capital in the Repo market and the concerns on collateral quality. Hence higher Repo indicates lower funding liquidity.

- Bond market illiquidity shock. We proxy market liquidity using the weekly innovations in both market Amihud measure(Amihud [2002]) and market Roll measure (Roll [1984]). The construction procedure of weekly innovations is similar to that in Lin et al. [2011]. Higher innovation in market Amihud measure or Roll measure means higher illiquidity shock to the bond market.

To get weekly market Amihud innovation, we first calculate weekly market Amihud measure as $Amihud_{Mt} = \sum_{j=1}^{5}\sum_{i=1}^{N}\frac{MC_i}{MC}Amihud_{ij}$, where $Amihud_{ij}$ is the individual Amihud measure (equation 2.4) for bond i at day j in a week, N is the number of bonds each day, and MC_i is the market capitalization of bond i, and MC is the total market capitalization. Then, we extract the innovations from the time series of weekly market Amihud measure using the following equation:

$$\Delta Amihud_{Mt} = \alpha_0 + \phi(\frac{M_{t-1}}{M_1})Amihud_{Mt-1} + \eta\Delta Amihud_{Mt-1} + \epsilon_t + \psi\epsilon_{t-1} \quad (2.6)$$

where $\Delta Amihud_{Mt}$ is the change in market Amihud measure from week t-1 to week t, M_t is the total trading dollar amount in week t. This equation accounts for the moving average effects. All the lags are determined by minimum information criteria based on BIC value. The estimated parameters are reported in Table 2.4 Panel A.

Weekly innovation on Roll measure is constructed similarly. Market weekly Roll measure is defined as $Roll_{Mt} = \sum_{j=1}^{5}\sum_{i=1}^{N}\frac{MC_i}{MC}Roll_{ij}$, where $Roll_{ij}$ is the individual Roll measure (equation 2.5) for bond i at day j in a week, N is the number of bonds each day, and MC_i is the market capitalization of bond i, and MC is the total market capitalization. Then, the innovation in Roll measure is calculated using the following regression:

$$\Delta Roll_{Mt} = \alpha_0 + \phi_1(\frac{M_{t-1}}{M_1})Roll_{Mt-1} + \epsilon_t \quad (2.7)$$

where $\Delta Roll_{Mt}$ is the change in market Roll measure from week t-1 to week t, M_t is the total trading dollar amount in week t. This equation accounts for the autocorrelation effects. All the lags are determined by minimum information criteria based on BIC value. The estimated parameters are reported in Table 2.4 Panel B.

C. Time varying risk premium

As discussed in section 1 and 2, the CDS basis should be more negative when the credit risk premium is higher, and for CDS bond pairs with larger difference in margin requirements.

A natural proxy for level the default risk premium would be the BAA_AAA spread, the difference between the yields of BAA and AAA rated corporate bonds, or the BAA Treasury spread (see Fama and French [1993]; Collin-Dufresne et al. [2001]; Lin et al. [2011]). We use Moody's BAA_AAA spread in this paper. Since the BAA and AAA bonds differ not only in credit risk, but also in liquidities, we would orthogonalize the spread on liquidity measures. Then we run the following regression to exclude the effects of autocorrelations. The market risk premium innovation is the residual term in the following equation:

$$\Delta Prem_t = \alpha_0 + \phi_1 Prem_{t-1} + \phi_2 \Delta Amihud_{Mt} + \phi_3 \Delta Roll_{Mt} + \eta \Delta Prem_{t-1} + \epsilon_t \quad (2.8)$$

where $\Delta Prem_t$ is the change in BAA_AAA spread from week t-1 to week t, $Prem_{t-1}$ is the BAA_AAA spread in week t-1, $\Delta Amihud_{Mt}$ is the change in market Amihud measure from week t-1 to week t, and $\Delta Roll_{Mt}$ is the change in market Roll measure from week t-1 to week t. All the lags are determined by minimum information criteria based on BIC value. The estimated parameters are reported in Table 2.4 Panel C.

D. Counterparty risk

Counterparty risk is proxied by the average daily stock return of the main dealers (Bai and Collin-Dufresne [2010]) [7] . When the average stock return of the primary dealers is low, the primary dealers are riskier, leading to higher concern about counterparty risk. If the counterparty risk is a major concern of the CDS buyers, we should observe that CDS spread decreases with a decrease in major dealers' stock return, driving CDS bond basis down.

E. Other controls

There are two technical reasons that could keep the CDS basis above zero, short constraint and cheapest-to-delivery option (Blanco et al. [2005]; Nashikkar et al. [2011]). To address the two problems, we include a dummy variable HY which equals 1 if the referenced bond is high-yield, and time to maturity of the reference bond. Since high-yield bonds are more difficult to short, their bond prices are more expensive relative to the CDS price (Nashikkar et al. [2011]). Hence, we expect a positive coefficient on HY. Regarding to the deliverable debt obligations under the same CDS contract, the ones with shorter maturity would be more expensive, leading to a higher CDS bond basis. Along the lines, the coefficient of time to maturity should be negative.

We also include VIX, which is CBOE's volatility index, to control for the market's expectation of near term volatility. Higher VIX is correlated with higher funding risk and higher risk premium. Hence, the expected coefficient on VIX is negative.

Summary Statistics

The sample consists of 242 firms, 711 bonds, and 53,904 firm-day observations during November 2006 and April 2009. The summary statistics of CDS bond basis by

[7] A list for current main dealers can be found at http://www.newyorkfed.org/markets/pridealers_current.html.

industry and by rating group are shown in Table 2.1. One third of the firms in the sample are financial firms, and one third is manufacturing firms. The CDS basis is winsorized at 1% and 99% to eliminate the outlier effect. The CDS basis is highest in pre-crisis period (November 2006 to June 2007), lower in crisis slowromancapi@ (July 2007 to August 2008), and lowest in crisis slowromancapii@ (September 2008 to April 2009) for every industry group, except the 2 construction firms. The basis is highest for construction firms, and lowest for real estate firms. For investment-grade reference entities, the basis is monotonically decreasing with the decrease in ratings, highest in pre-crisis period, and lowest in post Lehman/AIG bankruptcy period (crisis slowromancapii@). The relatively high average CDS basis on high-yield reference entities could be because of short selling constraint.

The summary statistics of variables used in this paper is reported in Table 2.2. Time series plots of the CDS basis against the potential determinants are shown in Table 2.6. The average basis for the whole sample period is -51.577 basis points (bps), for pre-crisis is -7.322 bps, for crisis slowromancapi@ is -33.145 bps, and for crisis slowromancapii@ is -168.449 bps. Although crisis slowromancapii@ has the same number of weeks as pre-crisis period, the number of observations in crisis slowromancapii@ is only one half of that in pre-crisis period, reflecting a decreasing liquidity in both CDS market and cash bond market. The increasing in Libor_OIS spread with time reflects an increasing in shadow cost and funding risk. The difference between Repo rates using mortgage backed security and government bonds as collateral increases in crisis slowromancapi@ , and then decreases in crisis slowromancapii@, indicating a hump-shaped funding cost in Repo market. Both Amihud and Roll measures increase with time, indicating a decreasing bond market liquidity. BAA_AAA spreads increase with time, showing an increasing credit risk premium. The mean value of stock return on primary dealers does not change much, but the standard deviation increases with time, indicating an increasing primary dealers' risk. The increasing in VIX reflects increasing expected short term volatility. The increasing in bond ratings reflect that the trades on CDS contract with high-yield reference entities decreased a lot in crisis period. The average time to maturity of bonds in the samples is 6.27 years. The correlations matrices using levels and changes of variables are shown in Table 2.3 Panel A.

2.4 Time Series Results

In this section, we report the effects and importance of funding costs, funding liquidity, credit risk premium, and counterparty risk in time series analysis. Since the dependent variable, the CDS basis, and the explanatory variables are highly auto-correlated, we use a difference-in-difference method. To further relieve the concern, we use market liquidity innovation and risk premium innovation calculated using arima regressions to proxy the changes in funding liquidity and credit risk premium. The following equation is estimated:

$$\Delta Basis_t = \alpha + \beta \Delta Control\_variable_t + \epsilon_t \tag{2.9}$$

Table 2.5 columns 1-6 report the effect of each determinant separately. Both proxies for funding cost are significant, yet the effect of Repo rates is more prominent both statistically and economically. One bps increase in Libor_OIS spread decreases the CDS basis by 0.151 bps, while one bps increase in MB_gov Repo decreases the CDS basis by 15.122 bps. The funding liquidity proxied by market liquidity measures are also significant and are as important as the funding cost measures in terms of R square. A one standard deviation increase in Amihud innovation decreases the CDS basis by 3.1 bps, and a one standard deviation increase in Roll innovation decreases the CDS basis by 2.53 bps. As projected, the CDS basis decreases with the increase in the credit risk premium. One bps increase in credit risk premium decreases the CDS basis by 0.44 bps. Considering the fact that the average BAA_AAA spread increases from

91 bps before crisis to 280 bps in post Lehman/AIG bankruptcy period, the effect of credit risk premium on the CDS basis is significant both statistically and economically. The effect of counterparty risk is not significant, which is consistent with Arora et al. [2011] that counterparty risk is minimal because of collateral requirements.

Table 2.5 columns 7-10 report the horse racing result using the full sample. The coefficients of Mb_gov Repo, Roll innovation, and risk premium innovation are always consistent and remain the same quality. Libor_OIS spread loses significance when the credit risk premium is included in the regression, indicating that the required return of capital is stronger in explaining the violation of the Law of One Price than the shadow cost of capital. Amihud innovation loses significance after controlling for funding costs, indicating that bond market liquidity, at least in form of Amihud measure, captures funding cost and availability. Moreover, the fact that adding market liquidity measure doubled the explanatory power of funding cost suggests that market liquidity is an important complement of funding cost in studying funding liquidity.

The regression results using investment-grades and high-yield firms only are reported in Table 2.6. While the results on investment-grade bonds mirror those on whole sample, the results on high-yield bonds are very different. The first observation is that the magnitude of the coefficients on funding liquidity related variables and credit risk premium in high-yield sample are much higher than those in investment-grade sample. The result is consistent with the margin-based story in that the investment in high-yield bonds requires more equity capital. The statistical explanatory powers of funding related variables in high-yield sample are much smaller than those in whole sample. But the explanatory power of risk premium innovation increases 60%. Surprisingly, the coefficient on Mb_gov Repo is marginally significant in a univariate test, and loses significance in the multivariate test. One possible explanation is that the Repo market for corporate bond collateral shrinks 3/4 in the dollar amount from 2007 Q2 to 2009 Q1. The shrinkage of Repo market on low credit rating collateral is even larger (Krishnamurthy et al. [2012]). It is possible that the Repo financing for high-yield bond became unavailable in the crisis period, rendering Repo rates irrelevant.

Furthermore, 1% decrease in the stock returns of primary dealers increases the CDS basis of high-yield firms by 3.3 bps. The result is not consistent with the prediction of the counterparty risk theory. Contrarily, the result suggests that, when the counterparty risk increases (primary dealers' stock return decreases), the HY firms' CDS spread increases more relative to their bond yield. One possible explanation is that the credit spreads of high-yield firms are more sensitive to the stock returns of primary dealers than bond yields.

2.5 Cross Sectional Results

To examine whether the funding costs, credit risk premium, and market liquidity are market factors priced in the CDS basis and their relative importance compared to counterparty risk, individual bond liquidity measures, margin requirement measures, and time to maturity, we perform Fama-MacBeth style cross-sectional tests in this section.

We first estimate the sensitivity of the CDS basis to each interested variable on a 90-day rolling window. The βs are defined as

$$\begin{aligned}
\beta_{Libor_OIS}(it) &= \frac{Cov(\Delta Basis_i, \Delta Libor_OIS)}{Var(\Delta Libor_OIS)} \\
\beta_{Repo}(it) &= \frac{Cov(\Delta Basis_i, \Delta Repo)}{Var(\Delta Repo)} \\
\beta_{Amihud}(it) &= \frac{Cov(\Delta Basis_i, \Delta Amihud_Market)}{Var(\Delta Amihud_Market)} \\
\beta_{Roll}(it) &= \frac{Cov(\Delta Basis_i, \Delta Roll_Market)}{Var(\Delta Roll_Market)} \\
\beta_{BAA-AAA}(it) &= \frac{Cov(\Delta Basis_i, \Delta BAA-AAA)}{Var(\Delta BAA-AAA)} \\
\beta_{Rpd}(it) &= \frac{Cov(\Delta Basis_i, \Delta Rpd)}{Var(\Delta Rpd)} \qquad (2.10)
\end{aligned}$$

where $\beta_*(it)$ is the sensitivity of CDS basis i to variable * between t-1 and t-90. Then we run the following regressions in each day

$$Basis_{it} = \alpha + \sum_{j=1}^{6} \beta_{ijt}\gamma_j(t) + \epsilon_{it} \tag{2.11}$$

$$\begin{aligned} Basis_{it} = \alpha + \sum_{j=1}^{6} \beta_{ijt}\gamma_j(t) + \phi_{1t}Amihud_{it} + \phi_{2t}Roll_{it} + \phi_{3t}Rating_{it} \\ +\phi_{4t}HY_{it} + \phi_{5t}TtM_{it} + \epsilon_{it} \end{aligned} \tag{2.12}$$

where β_{ijt} is firm i's basis sensitivity to factor j in day t estimated above. The individual liquidity measures and characteristics are defined in section 3.

The summary statistics of the coefficients estimated are reported in Table 2.7. The standard errors are adjusted using the Newey-West method, allowing for 15 lags. Overall, the risk premium associated with Repo, market Amihud, and BAA-AAA spread are all positive and significant, indicating that these factors are priced, even after controlling for individual liquidity measures and other characteristics. As shown in Table 2.7 columns 1-4, the magnitude of the coefficients increases with economic downturns.

Table 2.7 column 5 shows the average coefficients for the whole period using equation 2.12. One standard deviation increase in $\beta_{\Delta Libor\_OIS}$ increases the CDS basis by 11 bps, and one standard deviation increase in $\beta_{\Delta Repo}$ increases the CDS basis by 30 bps. One standard deviation increase in $\beta_{\Delta Amihud}$ increases the CDS basis by 9 bps, and one standard deviation increase in $\beta_{\Delta Roll}$ increases the CDS basis by 10 bps, which is not significant. One standard deviation increase in $\beta_{\Delta BAA-AAA}$ increases the CDS basis by 8 bps. Considering that one standard deviation in CDS basis is 125 bps, the impact of these factors are also economically significant. The cross-sectional results on the margin-related market factors suggest that investors require higher returns on the basis trades of which the margin requirements are more sensitive to changes in funding cost and market liquidity.

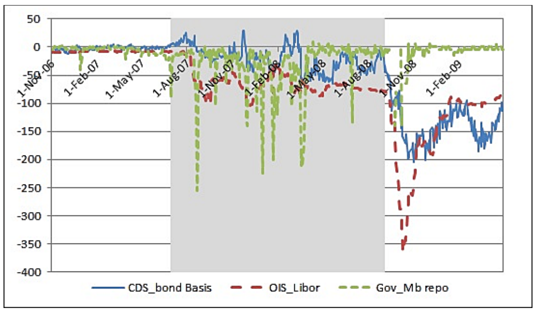
Table 2.7 column 5 also shows that one standard deviation increase in individual Amihud measure decreases the CDS basis by 6 bps, while one standard deviation increase in individual Roll measure decreases the CDS basis by 19 bps. The results confirm the findings in the literature that illiquid bonds are relatively cheaper. One notch decrease in credit rating decreases the CDS basis by 29 bps. It could be that the CDS basis trading of lower quality reference entities requires higher margins or higher risk-adjusted return. Being high-yield increases the CDS basis by 77 bps, which is consistent with the short-constraint story that the difficulty to short cash bond drives the CDS basis to the positive domain. The coefficient on HY becomes insignificant in the late crisis sample. One possible explanation of is that there are very few CDS contracts traded on HY bonds in that period. Finally, 1 year increase in time to maturity decreases the CDS basis by 3.6 bps, which is consistent with the cheapest-to-delivery argument. All coefficients are of expected signs.

To sum up, funding costs, market liquidity, and credit risk premium are factors priced in CDS basis. The pricing effect is more prominent in economic downturns but also significant in normal time.

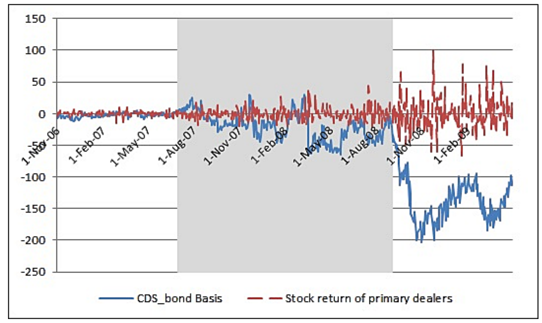
2.6 Conclusion

This paper tests the implications of the margin-based asset pricing theories using the CDS basis. Using single-name CDS data between November 2006 and April 2009, we show that (1) in a time series framework, the CDS basis decreases with higher funding costs, lower market liquidity, and higher credit risk premia; (2) cross-sectionally, CDS basis is more negative if it has higher beta sensitivities to funding costs, market illiquidity, or credit risk premia; and (3) the impact of the margin-related factors is always statistically and economically significant. The impact of the margin-related factors holds after controlling for counterparty risk, individual bond liquidity, short-constraint, and cheapest-to-delivery options.

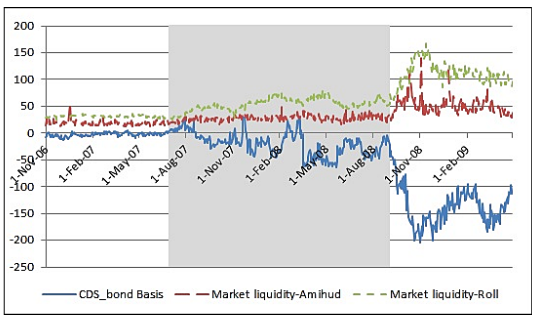
Our paper belongs to the growing literature that explains market anomalies from the perspective of funding liquidity and margin requirements (for example, Brunnermeier and Pedersen [2009]; Comerton-Forde et al. [2010]; Garleanu and Pedersen [2011]). Our paper suggests that the margin requirement is an important element of asset pricing.



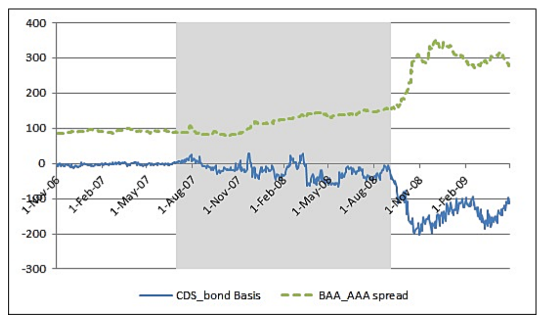
(a)Basis VS. Funding cost



(b)Basis VS. Counterparty risk



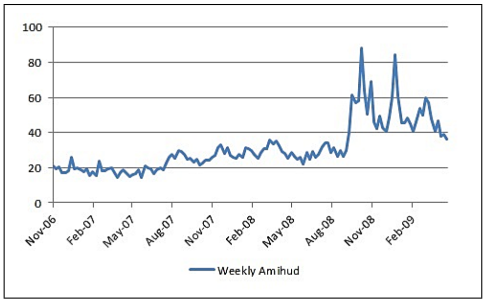
(c)Basis VS. Market liquidity



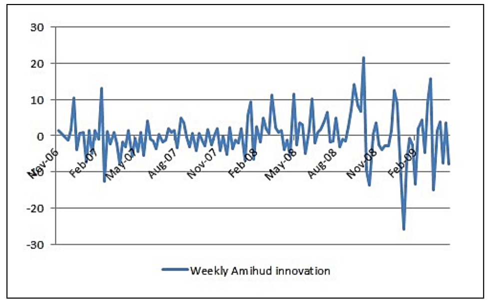
(d) Basis VS. Risk premium

Figure 2.1 The Determinants of the CDS Basis

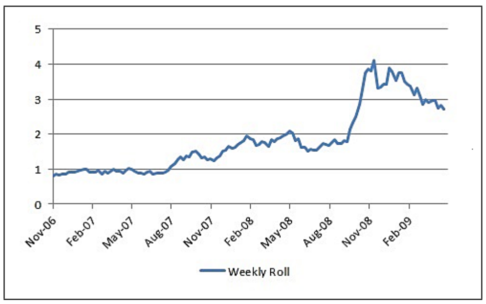
This figure shows the plots of daily average CDS basis against its theoretical determinants. CDS_bond basis is the difference between CDS spread and bond-implied CDS spread in basis points. OIS_Libor is the difference between overnight indexed swap rate and 3-month Libor rate in basis points. Gov_mb Repo is the difference between the Repo rates (in basis points) using government bonds and mortgage backed securities as collateral. Stock return of primary dealers is the market capitalization weighted daily average stock return of all the primary dealers listed in US. Market liquidity-Amihud (Roll) is the market capitalization weighted daily average Amihud (Roll) measure of all the bonds in the sample. BAA_AAA spread is the difference between the yields on Moody's BAA and AAA rated corporate bonds posted by Federal Reserve board. The left of the shaded area is normal time, Nov 2006 to Jun 2007. The shaded area is crisis slowromancapi@, Jul 2007 to Aug 2008. The shaded area is crisis slowromancapii@, Sep 2008 to Apr 2009.



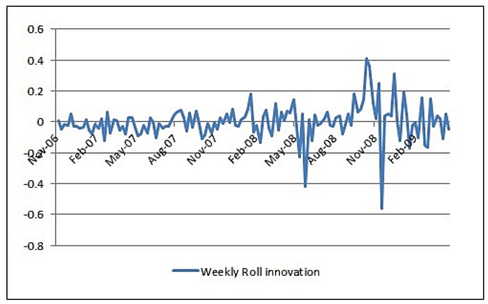
(a) Weekly Amihud



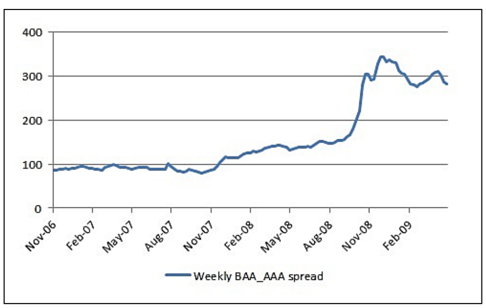
(b) Weekly Amihud innovation



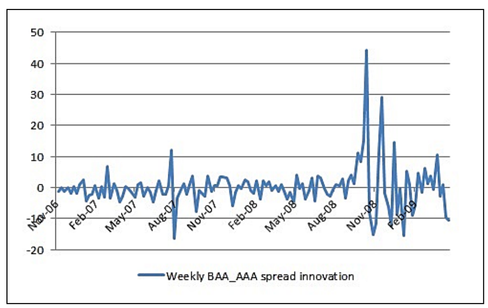
(c) Weekly Roll



(d) Weekly Roll innovation



(e) Weekly BAA_AAA spread



(f) Weekly BAA_AAA spread innovation

Figure 2.2 Market Liquidity and Credit Risk Premium

This table shows the weekly average market liquidity measures, default risk premium, and their innovations. Weekly Amihud (Roll) is weekly average daily Amihud (Roll) measures, which is the market capitalization weighted Amihud (Roll) measures of all bonds. Individual daily Amihud (Roll) is defined in equation 2.4 (equation 2.5). Weekly Amihud (Roll) innovation is the residual term using equation 2.6 (equation 2.7) which cleans auto-correlated and moving average components in the Amihud (Roll) time series. Weekly BAA_AAA spread is the weekly average BAA_AAA spread defined in the previous figure. Weekly BAA_AAA spread innovation is the residuals from equation 2.8.

Table 2.1 Summary Statistics of CDS Bond Basis

This table reports summary statistics of the CDS bond basis by industries and by ratings. The sample period is from Nov 2006 to April 2009. Number represents the number of firms in each category for the whole sample period. Pre-crisis is from Nov 2006 to Jun 2007. Early crisis is from Jul 2007 to Aug 2008, and late crisis is from Sep 2008 to Apr 2009.

Panel A. The CDS basis by industries and periods

Industry	Number	All	Pre-crisis	Early crisis	Late crisis
Finance	83	-51.439	-5.651	-32.363	-175.430
Non-durable goods	45	-32.369	-4.270	-16.833	-109.036
Durable goods	42	-46.790	-0.473	-28.831	-160.298
Retail	16	-65.704	-24.120	-57.653	-165.494
Utility	16	-40.863	-16.450	-51.869	-205.880
Transportation	15	-84.756	-4.888	-69.454	-281.055
Services	11	-85.357	-17.230	-48.407	-271.191
Other	14	-64.303	-21.013	-40.552	-169.180

Panel B. The CDS basis by rating group and periods

Rating	Number	All	Pre-crisis	Early crisis	Late crisis
AAA	6	-2.280	0.901	9.700	-29.610
AA	36	-20.693	-0.977	-3.263	-98.523
A	83	-44.732	-5.041	-29.109	-132.286
BBB	85	-116.950	-28.625	-89.243	-296.144
BB	14	-48.165	-18.964	-69.543	-165.338
B	15	23.946	31.514	35.599	-254.310
C	3	1.865	17.353	-4.373	-398.227

Table 2.2 Summary Statistics

This table shows the summary statistics of the variables in each period. Basis is the difference between CDS spread and bond-implied CDS spread in basis points. Libor_OIS is the difference between 3-month Libor rate and overnight index swap rate in basis points. Mb_gov Repo is the difference between Repo rates using mortgage backed securities and government bonds as collateral respectively in basis points. Amihud (Roll) is the daily Amihud measure calculated using equation 2.4 (equation 2.5). BAA_AAA is the spread between Moody's BAA and AAA rated bonds in basis points. Rpd is the daily market capitalization weighted average stock return of the US listed primary dealers. VIX is the VIX index published by CBOE. Rating is the S&P rating denoted in numbers, with AAA coded as 19 and CCC- coded as 1. TtM is the time to maturity of bonds in years.

Panel A. Summary statistics for whole periods

Variable	N	Mean	Maximum	Minimum	Std Dev
Basis	53904	-51.577	244.673	-601.053	125.481
Libor_OIS	53067	60.523	364.42	6.5	59.054
Mb_gov Repo	53023	17.64	255	-10	34.3
Amihud	53638	42.265	7972.664	0	104.469
Roll	47828	1.66	23.895	0.001	1.769
BAA_AAA	53904	141.709	350	77	76.502
Rpd	53904	0	0.275	-0.18	0.037
VIX	53904	24.059	80.86	9.89	13.827
Rating	53904	13.262	19	1	3.3
TtM	53904	6.274	30	1	5.08

Panel B. Summary statistics for normal time

Variable	N	Mean	Maximum	Minimum	Std Dev
Basis	18223	-7.322	244.673	-294.895	46.244
Libor_OIS	17927	8.316	11.56	6.5	0.824
Mb_gov Repo	18223	5.463	90	-2	8.724
Amihud	18191	28.259	6629.023	0	88.383
Roll	16237	0.916	10.061	0.001	0.827
BAA_AAA	18223	91.274	99	85	3.366
Rpd	18223	0.001	0.034	-0.043	0.01
VIX	18223	12.485	19.63	9.89	2.089
Rating	18223	12.793	19	1	3.544
TtM	18223	6.087	27	1	5.174

Panel C. Summary statistics for early crisis

Variable	N	Mean	Maximum	Minimum	Std Dev
Basis	24860	-33.145	244.673	-601.053	99.735
Libor_OIS	24428	62.587	106.35	7.7	22.302
Mb_gov Repo	24778	29.247	255	-10	43.813
Amihud	24722	39.819	2209.738	0	73.773
Roll	21952	1.564	12.324	0.006	1.298
BAA_AAA	24860	118.298	157	77	25.171
Rpd	24860	-0.001	0.119	-0.065	0.026
VIX	24860	22.465	32.24	14.72	3.605
Rating	24860	13.325	19	2	3.373
TtM	24860	6.471	30	1	5.113

Panel D. Summary statistics for late crisis

Variable	N	Mean	Maximum	Minimum	Std Dev
Basis	10821	-168.449	244.673	-601.053	185.058
Libor_OIS	10712	143.186	364.42	78.75	68.826
Mb_gov Repo	10022	11.084	150	-5	26.355
Amihud	10725	71.658	7972.664	0	166.071
Roll	9639	3.131	23.895	0.014	2.725
BAA_AAA	10821	280.426	350	153	53.791
Rpd	10821	0	0.275	-0.18	0.071
VIX	10821	47.21	80.86	21.43	12.157
Rating	10821	13.908	19	2	2.485
TtM	10821	6.139	30	1	4.821

Table 2.3 Correlation Matrix

Panel A shows the Pearson correlations of the variables on firm-day level. The variables are defined as in previous tables. Panel B shows the Pearson correlations of weekly changes in variables. Every variable is averaged weekly for all firms. The changes are calculated for basis, Libor_OIS, Mb_gov repo, Rpd, and VIX. Amihud, Roll, and risk premium innovations are the residual terms from the equation 2.6, 2.7, and 2.8.

Panel A. Correlation for whole sample

	Basis	Libor_OIS	Mb_gov Repo	Amihud	Roll	BAA_AAA	Rpd	VIX	Rating	TtM
Basis	1.000									
Libor_OIS	-0.397	1.000								
Mb_gov Repo	0.030	0.124	1.000							
Amihud	-0.211	0.145	0.021	1.000						
Roll	-0.515	0.390	0.008	0.315	1.000					
BAA_AAA	-0.494	0.717	-0.091	0.142	0.464	1.000				
Rpd	-0.008	-0.026	0.039	0.011	-0.008	0.012	1.000			
VIX	-0.447	0.859	0.086	0.148	0.446	0.885	-0.081	1.000		
Rating	0.072	0.114	0.020	-0.129	-0.177	0.109	-0.002	0.119	1.000	
TtM	-0.250	0.014	0.020	0.214	0.357	-0.015	-0.006	-0.001	-0.181	1.000

Panel B. Correlation for weekly changes

	Δ Basis	Δ Libor_OIS	Δ Mg Repo	Amihud innov	Roll innov	RP innov	Δ Rpd	Δ VIX
Δ Basis	1.000							
Δ Libor_OIS	-0.197	1.000						
Δ Mb_gov Repo	-0.322	0.131	1.000					
Amihud innovation	-0.271	0.332	0.225	1.000				
Roll innovation	-0.238	-0.130	0.033	0.115	1.000			
Risk prem innov	-0.246	0.191	-0.043	0.179	0.048	1.000		
Δ Rpd	-0.039	0.141	0.165	0.257	-0.085	0.034	1.000	
Δ VIX	-0.199	0.353	0.122	0.019	0.107	0.280	-0.111	1.000

Table 2.4 Market Liquidity Innovation and Risk Premium Innovation

This table shows the estimations of market liquidity innovations and risk premium innovation. The number of moving average and autocorrelation lags in the regressions is determined by minimum information criteria based on BIC value. Panel A shows the estimation of market liquidity innovation using Amihud measure. The estimated model is

$$\Delta Amihud_{Mt} = \alpha_0 + \phi(\frac{M_{t-1}}{M_1})Amihud_{Mt-1} + \eta\Delta Amihud_{Mt-1} + \epsilon_t + \psi\epsilon_{t-1}$$

where $\Delta Amihud_{Mt}$ is the change in market Amihud measure from week t-1 to week t, M_t is the total trading dollar amount in week t.

Panel B shows the estimation of market liquidity innovation using Roll measure. The estimated model is

$$\Delta Roll_{Mt} = \alpha_0 + \phi_1(\frac{M_{t-1}}{M_1})Roll_{Mt-1} + \epsilon_t$$

where $\Delta Roll_{Mt}$ is the change in market Roll measure from week t-1 to week t, M_t is the total trading dollar amount in week t.

Panel C shows the estimation of credit risk premium innovation using Moody's BAA_AAA spread. The estimated model is

$$\Delta Prem_t = \alpha_0 + \phi_1 Prem_{t-1} + \phi_2\Delta Amihud_{Mt} + \phi_3\Delta Roll_{Mt} + \eta\Delta Prem_{t-1} + \epsilon_t$$

where $\Delta Prem_t$ is the change in BAA_AAA spread from week t-1 to week t, $Prem_{t-1}$ is the BAA_AAA spread in week t-1.

Panel A. Market liquidity innovation using Amihud measure

Parameter	α_0	ϕ	η	ψ	R square
Estimate	1.742**	-0.054***	0.593***	0.866***	0.139
t Value	(2.570)	(-2.810)	(4.540)	(10.260)	

Panel B. Market liquidity innovation using Roll measure

Parameter	α_0	ϕ	R square
Estimate	0.054**	-0.031**	0.043
t Value	(2.600)	(-2.390)	

Panel C. Credit risk premium innovation using BAA_AAA spread

Parameter	α_0	ϕ_1	ϕ_2	ϕ_3	η	R square
Estimate	3.654	-0.015	-0.051	-3.695	0.579***	0.302
t Value	(1.150)	(-0.790)	(-0.670)	(-0.780)	(6.960)	

Table 2.5 Time Series Regressions

This table shows the results of time series regressions. The dependent variable is the weekly change in market capitalization weighted average CDS bond basis. The independent variables are defined in table 3. Regressions 1, 2, and 3 are testing the impact of funding cost proxied by Libor_OIS spread and the difference in Repo rates collateralized by mortgage backed securities and government bonds respectively. Regression 4 is testing the impact of bond market liquidity. Regression 5 is examining the impact of risk premium. Regression 6 is examining the impact of counterparty risk using average stock return of primary dealers as proxy. Table 7 tests the joint impact of funding cost and bond market liquidity. Table 8 tests the joint impact of funding costs, bond market liquidity, and risk premium. Table 9 tests the joint impact of funding costs, bond market liquidity, risk premium and counterparty risk. Table 10 tests the joint impact controlling for changes in VIX index. T-statistics are reported in parentheses. $^{***}p < .001$, $^{**}p < .05$, $^{*}p < .01$.

Δ Basis	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Intercept	-0.756	-0.846	-0.773	-0.848	-0.837	-0.848	-0.778	-0.785	-0.783	-0.757
	(-0.701)	(-0.813)	(-0.749)	(-0.818)	(-0.785)	(-0.773)	(-0.785)	(-0.809)	(-0.805)	(-0.774)
Δ Libor_OIS	-0.151**		-0.120*				-0.113*	-0.087	-0.088	-0.075
	(-2.251)		(-1.864)				(-1.698)	(-1.317)	(-1.330)	(-1.044)
Δ Mb_gov Repo		-15.122***	-14.155***				-12.422***	-13.375***	-13.592***	-13.299***
		(-3.824)	(-3.583)				(-3.207)	(-3.513)	(-3.537)	(-3.411)
Amihud innovation				-0.494***			-0.271	-0.213	-0.233	-0.248
				(-2.918)			(-1.542)	(-1.228)	(-1.305)	(-1.366)
Roll innovation				-22.988**			-25.535***	-24.251***	-23.743***	-23.005**
				(-2.484)			(-2.840)	(-2.753)	(-2.670)	(-2.545)
Risk premium innov					-0.440***			-0.370**	-0.370**	-0.350**
					(-2.850)			(-2.548)	(-2.538)	(-2.315)
Δ Rpd						-19.725			20.509	17.409
						(-0.455)			(0.509)	(0.426)
Δ VIX										-0.169
										(-0.502)
Observations	128	128	128	128	128	128	128	128	128	128
Adj R-Square	0.031	0.097	0.114	0.103	0.053	-0.006	0.181	0.216	0.211	0.206

Table 2.6 Time Series Regressions by IG/HY

This table shows the time series regression results on investment-grade and high-yield bonds separately. The variables and regressions are defined in the previous table. T-statistics are reported in parentheses. $^{***}p < .001$, $^{**}p < .05$, $^{*}p < .01$.

Panel A. Time series regression for investment-grade bonds

Δ Basis	(1)	(2)	(3)	(4)	(5)
Intercept	-0.733	-0.799	-0.792	-0.804	-0.700
	(-0.710)	(-0.773)	(-0.748)	(-0.738)	(-0.712)
ΔLibor_OIS	-0.114*				-0.056
	(-1.760)				(-0.781)
ΔMb_gov Repo	-13.233***				-12.273***
	(-3.349)				(-3.147)
Amihud innovation		-0.426***			-0.230
		(-2.746)			(-1.375)
Roll innovation		-21.646**			-20.012**
		(-2.505)			(-2.346)
Risk premium innov			-0.425***		-0.324**
			(-2.776)		(-2.132)
ΔRpd				-22.140	7.555
				(-0.514)	(0.182)
ΔVIX					-0.265
					(-0.786)
# of weeks	128	128	128	128	128
Adj R-Square	0.100	0.095	0.050	-0.006	0.186

Panel B. Time series regressions for high-yield bonds

Δ Basis	(1)	(2)	(3)	(4)	(5)
Intercept	-0.680	-0.892	-0.868	-1.575	0.472
	(-0.147)	(-0.191)	(-0.189)	(-0.337)	(0.111)
ΔLibor_OIS	-0.653**				-0.149
	(-2.358)				(-0.534)
ΔMb_gov Repo	-29.309*				-25.251
	(-1.795)				(-1.657)
Amihud innovation		-1.042*			-1.075**
		(-1.733)			(-1.985)
Roll innovation		169.455***			166.154***
		(2.810)			(3.024)
Risk premium innov			-2.165***		-2.057***
			(-3.252)		(-2.976)
ΔRpd				-331.928**	-467.530***
				(-2.519)	(-3.346)
ΔVIX					-1.679
					(-1.114)
# of weeks	113	113	113	113	113
Adj R-Square	0.066	0.051	0.079	0.046	0.234

Table 2.7 Cross Sectional Regressions

This table shows the statistics of Fama-MacBeth style daily cross sectional regression coefficients. The betas are defined as

$$\beta_{Libor\_OIS}(i)= \frac{Cov(\Delta Basis_i,\Delta Libor\_OIS)}{Var(\Delta Libor\_OIS)}$$
$$\beta_{Repo}(i)= \frac{Cov(\Delta Basis_i,\Delta Repo)}{Var(\Delta Repo)}$$
$$\beta_{Amihud}(i)= \frac{Cov(\Delta Basis_i,\Delta Amihud\_Market)}{Var(\Delta Amihud\_Market)}$$
$$\beta_{Roll}(i)= \frac{Cov(\Delta Basis_i,\Delta Roll\_Market)}{Var(\Delta Roll\_Market)}$$
$$\beta_{BAA-AAA}(i)= \frac{Cov(\Delta Basis_i,\Delta BAA-AAA)}{Var(\Delta BAA-AAA)}$$
$$\beta_{Rpd}(i)= \frac{Cov(\Delta Basis_i,\Delta Rpd)}{Var(\Delta Rpd)}$$

where each β is estimated for each CDS-bond pair on a 90-day rolling window and the changes in variables are calculated daily. Other variables are defined in the previous tables. The cross section regression in each day is $Basis_{it} = \alpha + \sum_{j=1}^{6} \beta_{ijt}\gamma_j(t) + \epsilon_{it}$ and $Basis_{it} = \alpha + \sum_{j=1}^{6} \beta_{ijt}\gamma_j(t) + \phi_{1t}Amihud_{it} + \phi_{2t}Roll_{it} + \phi_{3t}Rating_{it} + \phi_{4t}HY_{it} + \phi_{5t}TtM_{it} + \epsilon_{it}$. The standard errors of estimated parameters are adjusted using Newey-West method. T-statistics are reported in parentheses. ***$p < .001$, **$p < .05$, *$p < .01$.

	All	Normal	Crisis 1	Crisis 2	All	Normal	Crisis 1	Crisis 2
β_{Libor_OIS}	2.507	0.761***	-3.725	15.332**	1.97	0.193**	-3.072	12.672***
	(2.435)	(0.078)	(2.389)	(6.546)	(1.902)	(0.095)	(1.965)	(4.514)
β_{Repo}	0.348***	0.013	0.735***	-0.05	0.249**	0.001	0.549***	-0.073
	(0.118)	(0.015)	(0.211)	(0.048)	(0.115)	(0.009)	(0.211)	(0.06)
β_{Amihud}	11.033***	1	9.984**	21.901**	13.891***	5.735***	11.279***	25.909**
	(3.498)	(1.64)	(4.442)	(9.191)	(4.102)	(1.375)	(4.19)	(12.47)
β_{Roll}	0.088	-0.033	-0.106***	0.548***	0.048	-0.042	-0.009	0.231*
	(0.065)	(0.028)	(0.04)	(0.174)	(0.043)	(0.031)	(0.025)	(0.136)
$\beta_{BAA-AAA}$	2.311***	0.607	1.554**	5.205***	2.382***	1.044***	1.518**	5.14***
	(0.682)	(0.472)	(0.779)	(1.801)	(0.601)	(0.358)	(0.609)	(1.602)
β_{Rpd}					196.513	-12.961	111.576	537.388
					(124.207)	(20.988)	(136.381)	(364.802)
Amihud					-0.107***	-0.009	-0.091***	-0.223***
					(0.021)	(0.017)	(0.023)	(0.046)
Roll					-12.899***	-2.886**	-11.044***	-25.207***
					(2.228)	(1.304)	(3.15)	(3.062)
Rating					8.896***	0.85**	5.805***	21.678***
					(1.558)	(0.392)	(0.965)	(2.603)
HY					77.579***	61.014***	136.341***	-13.812
					(12.968)	(4.922)	(11.241)	(19.731)
Time-to-maturity					-3.632***	-5.195***	-4.292***	-1.041
					(0.446)	(0.224)	(0.299)	(1.21)
Intercept	-44.237***	-2.247***	-21.105***	-123.6***	-151.56***	10.893	-82.016***	-422.55***
	(7.787)	(0.563)	(4.648)	(6.972)	(32.084)	(6.601)	(20.028)	(48.432)
Ave # Firms	86	110	85	67	86	110	85	67
# of days	596	144	291	161	596	144	291	161
R-Square	0.175	0.178	0.168	0.187	0.512	0.595	0.475	0.505
Adj R-Square	0.106	0.127	0.099	0.1	0.414	0.535	0.372	0.382

Chapter 3

Capital Structure along the Supply Chain: How Does Customer Leverage Affect Supplier Leverage Decisions?

3.1 Introduction

Firms often have close connections with their major customers, and, therefore, the major customers may play important roles in shaping firms' real and financial decisions. While the supply chain literature has extensively studied the effects of customers on corporate real decisions (for example, Vidal and Goetschalckx [1997] and Cohen and Lee [1988]) and the recent corporate finance literature has studied the effects of various customer characteristics on corporate financial policies (for example, Hennessy and Livdan [2009] and Kale and Shahrur [2007]), very few studies have examined the relationship between the financial policies of suppliers and those of their customers. This paper presents the first effort to study how a customer's leverage affects its supplier's leverage choice.

We invoke two theories of capital structure, the bargaining theory and the relation-specific investment theory, to develop two competing hypotheses on the leverage relationship between a firm and its customer. The bargaining theory argues that debt improves a firm's bargaining position against its customers or suppliers (for example, Bronars and Deere [1991]; Dasgupta and Sengupta [1993]; Hennessy and Livdan [2009]; Chu [2012]). When a customer increases its leverage, it increases its bargaining power against its supplier. The supplier, unwilling to lose its bargaining power, may respond by increasing its own leverage. Therefore, the bargaining theory predicts a positive leverage relationship between the supplier and its customer. However, the relation-specific investment theory argues that debt discourages relation-specific investments made by both the supplier and the customer (Kale and Shahrur [2007]; Hennessy and Livdan [2009]; and Chu [2012]). To mitigate the debt-induced investment inefficiency, the supplier will not increase its leverage when the customer increases leverage. The relation-specific investment theory, therefore, predicts a negative leverage relationship between the supplier and its customer.

To examine these two mechanisms of the leverage relationship, we test the implications of these theories. According to the bargaining theory, if the supplier has a lower *ex-ante* bargaining power, it has more incentive to use debt as a bargaining tool. The supplier, therefore, becomes more sensitive to its customer's leverage change if its own *ex-ante* bargaining power is lower or if its customer's *ex-ante* bargaining power is higher. As a result, the positive leverage relationship becomes stronger if the customer's *ex-ante* bargaining power is higher. According to the relation-specific investment theory, however, if the nature of the relationship between the supplier and its customer requires more relation-specific investments, the supplier has to reduce its own leverage more aggressively if the customer increases its leverage. Therefore, the positive leverage relationship becomes weaker or even negative if relation-specific investments are more important to the supplier-customer relationship.

We use the Compustat Segment data set to examine the leverage relationship between suppliers and customers. The Segment data allows us to identify the primary customers who account for more than 10% of a firm's total sales. We include the primary customer's leverage in an otherwise standard capital structure regression and find that the firm's leverage is positively associated with its customer's leverage after controlling for other well-documented capital structure determinants.

We proceed by investigating the bargaining theory and the relation-specific investment theory of capital structure. To test the implications of the bargaining theory, we construct three proxies to measure the customer's *ex-ante* bargaining power based on the customer firm size, the customer's price-cost margin and the customer's industry Herfindahl index. Using these three proxies, we find that the positive leverage relationship is stronger when the customer has more bargaining power. To test the implications of the relation-specific investment theory, we construct two proxies to measure the importance of relation-specific investments. The first measure is the customer's industry median research and development (R&D) intensity, and the second measure is an indicator of whether the customer is in a durable goods industry. According to Titman and Wessels [1988]; Kale and Shahrur [2007]; and Banerjee et al. [2008], relation-specific investments are more important when the industry median R&D intensity is high or if the customer firm is in a durable goods industry. Using both measures, we find that the positive leverage relationship is weaker when relation-specific investments are more important. Collectively, our results suggest that, while relation-specific investments are more important in determining customer-supplier leverage decisions for firms in the durable goods industries, bargaining power is more important in non-durable goods industries.

For robustness checks, we also show that the positive leverage relationship is not merely due to local or industry-specific shocks that simultaneously affect the supplier and the customer's leverage decisions. To further address the endogeneity problem of the customer's leverage, we follow Leary and Roberts [2014] to use the customer's idiosyncratic volatility as the instrument for customer leverage, and we find that the positive leverage relationship holds in two-stage least squares estimations with the instrument.

To the best of our knowledge, our paper is the first study on how bargaining power shapes the relationship between a firm and its customers' leverage ratios. The existing literature on the relationship between a firm's leverage and its customer's characteristics, such as Kale and Shahrur [2007] and Banerjee et al. [2008], shows that a firm tends to lower its leverage when it has important customers. Moreover, this relationship could be explained by the relation-specific investment theory. We show that they also tend to increase the leverage ratio to maintain their bargaining power. We, therefore, complement their analysis and contribute to the literature by recognizing the importance of bargaining power in the supplier-customer relationship. Our paper also show evidence that, except for the labor union, firms are likely to bargain with other stakeholders, such as their suppliers and customers. It has been shown that firms increase their leverage ratio to bargain with their labor unions and employees in general (Bronars and Deere [1991], Dasgupta and Sengupta [1993], Perotti and Spier [1993], Cavanaugh and Garen [1997], Hanka [1998], Matsa [2010], and Benmelech et al. [2012]). Our paper extends this strand of literature by showing that firms could increase their leverage ratio to bargain with a broader category of stakeholders.

The rest of the paper is organized as follows. Section II describes related literature and develops the hypotheses. Section III describes the data and the sample construction method. Section IV presents estimates of the leverage relationship and examines the mechanism of the leverage relationship. Section V shows the robustness tests. Section VI concludes the paper.

3.2 Hypothesis Development

We invoke two non-mutually exclusive theories of capital structure to explain the leverage relationship between a supplier and its customer: the bargaining theory and the relation-specific investment theory. In this section, we first review the literature on these two theories and develop testable hypotheses according to the implications of the theories. We then briefly review other closely related literature.

Leverage and Bargaining Power

Bronars and Deere [1991] argue that firms can use debt as a bargaining tool to reduce the surplus that labor unions can extract. They also empirically show that firms facing a greater threat of unionization use debt more aggressively. Dasgupta and Sengupta [1993] develop a bargaining model to show that debt improves a firm's bargaining power against its employees or suppliers. Hennessy and Livdan [2009] put the supplier-customer relationship within a relational contract framework and show that debt decreases the amount of surplus the suppliers can extract, and thereby increases the firm's bargaining power against its suppliers. Empirically, Kale and Shahrur [2007] find that when a firm's customers or suppliers have higher bargaining power (measured by the industry Herfindahl index), the firm tends to have higher leverage. Matsa [2010] also find that firms with higher labor union coverage use higher leverage. The above-mentioned literature all suggests that debt improves a firm's bargaining power against its employees, customers or suppliers. Thus, what does the bargaining theory imply about the leverage relationship between suppliers and customers?

According to the bargaining theory, when the customer increases its leverage, it increases its bargaining power against its supplier. The supplier, unwilling to lose its bargaining power, then responds by increasing its own leverage to improve its bargaining power. Therefore, the bargaining theory suggests that the supplier's leverage and its customer's leverage should be positively associated. Furthermore, the bargaining theory also suggests that the leverage relationship is likely to be affected by the *ex-ante* bargaining power of the supplier and the customer. If the customer has a higher *ex-ante* bargaining power and increases its leverage, its supplier will find itself in a much worse bargaining position and will, therefore, increase its leverage more aggressively. As a result, the positive leverage relationship becomes stronger if the customer has more bargaining power. We summarize below two hypotheses based on the bargaining theory.

Hypothesis 1A: According to the bargaining theory of capital structure, a supplier's leverage is positively associated with its customer's leverage.

Hypothesis 1B: The positive leverage relationship between a supplier and its customer is stronger if the customer has more *ex-ante* bargaining power.

Because the way in which the *ex-ante* bargaining power affects the leverage relationship depends on whether the leverage relationship is positive or negative, we have a different version of Hypothesis 1B in case of a negative leverage relationship:

Hypothesis 1C: The negative leverage relationship between the supplier and its customer is weaker if the customer has more *ex-ante* bargaining power.

Leverage and Relation-Specific Investments

Titman [1984] shows that a firm's liquidation policy can affect its customer's welfare and that the firm can commit to a liquidation policy by choosing a lower leverage. Implicit in Titman' analysis is that the customer makes relation-specific investments and that these investments lose value once the firm goes into liquidation. Maksimovic and Titman [1991] further show that high leverage reduces a firm's incentive to invest in its reputation and product quality. More recently, Hennessy and Livdan [2009] study the effect of leverage on relation-specific investments from a different perspective. They show that high leverage reduces a firm's ability to pay the suppliers incentive payments to make relation-specific investments. Based on these theoretical insights, Kale and Shahrur [2007] find that firms lower their leverage to induce suppliers and customers to make relation-specific investments. In summary, the relation-specific investment theory suggests that a firm's leverage reduces its customer's incentive to make relation-specific investments, and the firm, therefore, chooses lower leverage to induce its customers to make efficient investments. What does the relation-specific investment theory of leverage imply about the leverage relationship between the supplier and its customer?

To fix the idea, we consider the case in which the customer has increased its leverage for some exogenous reasons. On one hand, according to the relationship-specific investment theory, the customer's high leverage will decrease the supplier's relationship-specific investments. On the other hand, according to the under-investment theory of Myers [1977], the customer's high leverage will also decrease the customer's own investment, which may also include customer's relationship-specific investment to the supply chain. Consequently, to mitigate such investment inefficiencies caused by customer's high leverage, the supplier can respond by reducing his own leverage, which, according to the relationship-specific investment theory, will increase the customer's relationship-specific investment, and according to the under-investment theory, will increase the supplier's own investment. The above discussion, therefore, suggests a negative relationship between the supplier and customer leverages.

Hypothesis 2A: According to the relation-specific investment theory of capital structure, a supplier's leverage is negatively associated with its customer's leverage.

Hypothesis 2B: The negative leverage relationship between a supplier and its customer is stronger if the relation-specific investments are more important.

Because the way in which the importance of relation-specific investments affects the leverage relationship depends on whether the leverage relationship is positive or negative, we have a different version of Hypothesis 2B for the case of a positive leverage relationship:

Hypothesis 2C: The positive leverage relationship between the supplier and its customer is weaker if relation-specific investments are more important.

3.3 Data

Sample Construction

Our sample consists of all supplier-customer pairs that can be identified in Compustat between 1976 and 2009. According to the FASB 14 (1976) and 131 (1997), public firms are required to disclose customers who account for at least 10% of total sales. While these disclosures are available in the Compustat segment files, the primary customers are only reported with abbreviated names and without any other identifiers. We use a method similar to that of Fee and Thomas [2004] to match the reported customer names to Compustat firms. From the Compustat segment data file, we first discard all of the customers that are reported as governments, regions, or militaries. We then run a text matching program to find the potential matches of the reported customer name with the Compustat firm names. The program requires all of the letters in the reported customer name to be sequentially presented in the potential match. For example, “FAIRCHLD CAM" can be matched with “FAIRCHILD CAMERA & INSTRUMENT", while “FIARCHLD CAM" and “FAIRCHLD CAMZ" cannot be matched with“FAIRCHILD CAMERA & INSTRUMENT". We also manually identify customers from the matched pairs from the text matching program. If there are multiple potential matches and we cannot choose the unique match by screening the available public information (Firm websites, annual reports, and Google), we conservatively discard all these possible firm-customer pairs. We also drop all utility firms (SIC code range from 4900 to 4999) and financial firms (SIC code range from 6000 to 6999). Our sample selection procedure results in a total of 8,645 firm customer pairs and 35,153 firm customer years. From the 35,153 firm-year observations, we delete any observations for which the total assets or sales are either zero or negative. We also delete any firm-year observations with missing data.

Leverage Measures

We use two leverage measures, *Market Leverage* and *Book Leverage.* We define the *Market Leverage* as the book value of total debt (debt in current liabilities (dlc) + long term debt (dltt)) divided by the market value of asset (Market value of equity (csho*prcc_c) + debt in current liabilities (dlc) + long-term debt (dltt) + preferred liquidation value (pstkl) - deferred taxes and investment credit (itcb)), and define the *Book Leverage* as the book value of total debt divided by the book value of total assets (at).

Measures of *ex-ante* Bargaining Power

We use three measures of the customer's *ex-ante* bargaining power. The first measure is the customer's firm size. According to Chipty [1995], Ellison and Snyder [2010], and Sorensen [2003], large customers often have more bargaining power against their suppliers and receive more discounts from their suppliers.

The second measure is the customer's price-cost margin as defined below:

$$\textit{Price-Cost Margin} = \frac{\textit{Sales-Cost of Goods Sold} + \textit{Change in Inventory}}{\textit{Sales} + \textit{Change in Inventory}} \tag{3.1}$$

The price-cost margin is generally considered as a measure of industry competition, and therefore it can be used to measure the customer's *ex-ante* bargaining power (Kale and Shahrur [2007] and Chu [2012]). Furthermore, a higher price-cost margin can only come from two sources: a higher output price, a lower input cost, or both. If the customer firm has more bargaining power against its suppliers, its input cost is lower, and, therefore, the price-cost margin is higher.

The third measure is the customer firm's industry (4-digit SIC) Herfindahl index, which also measures industry competitiveness. We calculate the industry Herfindahl index based on all Compustat firms in the 4-digit SIC industry. However, as documented in Ali et al. [2009], the Compustat based Herfindahl index is a poor proxy for industry competition. Ali et al. [2009] also suggest using the census-based Herfindahl index as a better measure of industry concentration. However, the census data only cover manufacturing firms for a short period of time and, therefore, do not satisfy our needs in this paper. We therefore still use the Compustat-based Herfindahl index as one measure of the customer's *ex-ante* bargaining power. Due to the potential limitation of the Herfindahl index, we will interpret the results using the Herfindahl index with more caution.

Measures of the Importance of Relation-specific Investments

We use two measures of the importance of relation-specific investments. We first follow Kale and Shahrur [2007] and use the customer's industry median R&D intensity as a measure of the importance of relation-specific investments. If the industry median R&D intensity is high, the industry requires more relation-specific investments, and, therefore, relation-specific investments are more important (Kale and Shahrur [2007]). The second measure is an indicator of whether the customer firm is in a durable goods industry (SIC code 3400-3990). According to Titman and Wessels [1988] and Banerjee et al. [2008], firms in durable goods industries require more relation-specific investments.

Control Variables

In addition to the main variables of interest, we follow the literature (Titman and Wessels [1988], Frank and Goyal [2009], and Leary and Roberts [2014]) and include the following control variables (all lagged by one year) in the capital structure regressions:

- *Firm Size* - the log of total book assets (at).
- *Profitability* - operating income (oibdp) divided by total assets (at).

- *Tangibility* - net property, plant and equipment (ppent) divided by total assets (at).
- *Market-to-Book* - market value of assets (Market value of equity (csho*prcc_c) + Debt in current liabilities (dlc) + long term debt (dltt) + preferred liquidation value (pstkl) - deferred taxes and investment tax credit (itcb))divided by total assets (at).
- *Industry Median Leverage* - The median leverage of the 4-digit SIC industry (excluding the firm itself).

Summary Statistics

Table 3.1 presents summary statistics for suppliers and customers, respectively. All variables are winsorized at the 1% and 99% level.[1] As shown in Table 3.1, customer and supplier firms differ significantly along multiple dimensions. Most noticeably, the customer firms are much larger (about 147 times larger) and more profitable than the supplier firms.

3.4 The Leverage Relationship

In this section, we first examine the overall relationship between suppliers and customers' leverage ratios. Then, we examine the two possible theories governing the relationship.

The overall leverage relationship

We first run OLS regressions to examine the relationship between customer leverage and supplier leverage. Panel A of Table 3.2 reports the regression results with the

[1] The empirical results are qualitatively the same without winsorizing

supplier's market leverage as the dependent variable. Column (1) reports the ordinary least square estimates with year fixed effects only. Column (2) includes supplier industry fixed effects. Column (3) includes customer firm controls to address the concern that some customer firm controls (customer *R&D Intensity*, for example) may simultaneously affect both its own leverage and its supplier's leverage. Column (4) includes instead the supplier fixed effects to address the concern of unobserved effects (Lemmon et al. [2008]). Column (5) includes supplier-customer pair fixed effects to address the concern that unobserved effects of the supplier-customer pair may contribute to the leverage relationship. The standard errors reported in Table 3.2 are clustered by customer-year because many customer firms are reported by multiple suppliers as their primary customers, for example, AT&T was reported by 40 firms on average as their primary customer.[2] The results show that *Customer Leverage* has a positive and statistically significant effect on its supplier's leverage across all specifications.

The positive leverage relationship is also economically significant. The magnitude of the coefficients on *Customer Leverage* ranges from 0.037 to 0.060, which implies that one standard deviation change in the customer's leverage (22.7%) can change its supplier's leverage by 0.80 to 1.36 percentage points or 3.67% to 5.95% of the average supplier's leverage. A comparison of the economic significance of all supplier controls shows that the economic significance of the customer's leverage is only smaller than *Firm Size*, *Profitability*, and *Tangibility*, but is greater than *Market-to-Book* and *R&D Intensity*.

The effects of most control variables in Panel A are consistent with the existing literature (for example, Frank and Goyal [2009]). Consistent with the findings in

[2]Throughout the paper, we will report the standard errors clustered by customer-year. However, many supplier firms also report multiple customers, and it is, therefore, important to adjust the standard error by clustering supplier-year. It turns out that all results reported in this paper are robust to standard errors cluster by supplier-year and also the generic robust standard errors

Kale and Shahrur [2007], we also find that *Customer R & D Intensity* has a negative effect on supplier leverage; however, the negative effect is not statistically significant. To corroborate with their findings, we exclude *Customer Leverage* from the regression and find that *Customer R & D Intensity* is statistically significant in this case. However, the statistical significance is not robust to firm fixed effects. These results suggest that at least part of the negative effect of *Customer R & D Intensity* on supplier leverage is caused by the positive leverage relationship, which also suggests that the positive leverage relationship may be a more important link between the supplier and the customer.

Panel B of Table 3.2 shows that a similar positive leverage relationship exists between book leverages, which suggests that the positive market leverage relationship is not due to passive changes in the market value of equity or the accumulation of retained earnings.

The Mechanism

The above empirical results are consistent with the bargaining power theory of capital structure that firms compete with their customers in the leverage ratio. We proceed to examine whether they do so to maintain their bargaining power and whether the relation-specific investment theory plays a role in the leverage relationship. As discussed in the literature review section, the bargaining theory predicts that the positive leverage relationship becomes stronger if the customer has more bargaining power (Hypothesis 1B) and the relation-specific investment theory predicts that the positive relationship becomes weaker if relation-specific investments are more important (Hypothesis 2C). This section tests these two predictions.

The Effects of the Customer' Bargaining Power

To test the effects of a customer's bargaining power, we first rank the customer firms according to three measures of their *ex-ante* bargaining power: the firm size, the price-cost margin, and the industry Herfindahl index. We then construct three indicators: $Large = 1$ if the log assets of the customer firm is greater than two times of the annual industry median log assets, and $Large = 0$ otherwise.[3] $Power = 1$ if the price-cost margin of the customer firm is greater than the annual industry median price-cost margin, and $Power = 0$ otherwise. $Concentration = 1$ if the customer firm's industry Herfindahl index is higher than the annual median Herfindahl index of the sample, and $Concentration = 0$ otherwise. We then interact these indicators with *Customer Leverage* to create the interaction terms. The bargaining theory predicts that the interaction terms should carry positive signs if incorporated in the capital structure regressions.

To estimate equations with these interaction terms, we again use *Idiosyncratic Return* and its interaction with *Large*, *Power*, and *Concentration* as the instruments. We present the estimation results for market leverage in Panel A of Table 3.3. The results show that the coefficients on all of the interaction terms are positive and statistically significant, which suggests that the positive leverage relationship becomes stronger when the customer has more bargaining power. In fact, when the customer has a lower price-cost margin ($Power = 0$), the marginal effect of the customer's leverage is statistically insignificant. These results suggest that bargaining power plays an important role in establishing the positive leverage relationship. The results also show that the marginal effect of bargaining power (evaluated at the sample mean of the customer's leverage) on the supplier's leverage is positive, which is consistent with the view that the customer bargaining power increases its supplier's incentive to

[3]The customer firms in our sample are large firms relative to their industry peers; therefore we choose the threshold to be two times the industry median instead of just the median.

use leverage as a bargaining tool (Chu [2012], Hennessy and Livdan [2009], and Kale and Shahrur [2007]). Panel B of Table 5 shows similar results for book leverage.

The Effects of Relation-Specific Investments

We next use the same strategy to examine the effects of the importance of relation-specific investments. We construct two indicator variables: $Relation = 1$ if the customer industry median R & D is positive, and $Relation = 0$ if the customer industry median R & D is 0. $Durable = 1$ if the customer SIC code is between 3400 and 3990, and $Durable = 0$ otherwise. We present the instrumental variable estimation results for market leverage in Panel A of Table 3.4. The results show that the positive leverage relationship is weaker when relation-specific investments are more important ($Relation = 1$) or when the customer firm is in a durable goods industry ($Durable = 1$). This result is consistent with the view that when relation-specific investments are important, the supplier chooses a lower leverage to encourage relation-specific investments (Kale and Shahrur [2007]). Furthermore, the results also show that the marginal effect of the importance of relation-specific investments (evaluated at the sample mean customer leverage) on the supplier's leverage is negative, which is consistent with the findings in Kale and Shahrur [2007].

The above results also complement the findings in Banerjee et al. [2008]. They find that firms with dependent customers or suppliers use lower leverage if the firms are in durable goods industries, which is consistent with the relation-specific investment theory. Our analysis in this paper, while confirming the role played by relation-specific investments, suggests that bargaining power is as important and is probably more important for firms in non-durable goods industries.

3.5 Alternative Explanations and Robustness Tests

This section presents our efforts in mitigating the concerns regarding a spurious leverage relationship. In particular, we investigate whether the positive leverage relationship is caused merely by common shocks to the customers and suppliers, and whether the positive leverage relationship is caused by the characters of the supplier-customer industries rather than that of the individual supplier-customer pairs. Also, we conduct robustness tests using instrumental variables and other methods.

Leverage Relationship and Common Shocks

One obvious explanation for the positive leverage relationship other than bargaining power is that the supplier and the customer are subject to economic shocks that simultaneously affect the supplier and the customer's leverage decisions. One such shock can be a local shock which affects all firms in the same geographical area.[4] To examine whether the positive leverage relationship is due to local shocks, we split the sample into two sub-samples according to whether the supplier and the customer are in the same state. If the positive leverage relationship is due to local shocks, we should observe no relationship, or at least weaker relationship if the supplier and the customer are not in the same state. We show the results using the two sub-samples in Table 3.5, with Panel A for market leverage and Panel B for book leverage. Comparing the results using these two sub-samples, while the positive leverage relationship is slightly stronger when the supplier and the customer are in the same state, the positive leverage relationship remains significant when the supplier and the customer are not in the same state. The results suggest that the positive leverage relationship

[4]Macroeconomic shocks that affect all firms in the economy are unlikely to explain the positive leverage relationship because we control year fixed effects in the OLS regressions

between the supplier and the customer is unlikely due to local economic shocks.[5]

The other shock that may lead to the positive leverage relationship is industry-specific shocks, which may simultaneously affect the supplier industry and the customer industry. To examine whether the positive leverage relationship is due to industry-specific shocks, we carry a matching exercise.

We first match, for each customer firm in our sample, a firm in the same industry as the customer firm that has similar characteristics as the customer firm. We match on customer firm's capital structure determinants and use the Euclidean metric weighted by the inverse of a variance-covariance matrix to measure the distance between firms. We choose the firm that is closest to the customer firm in the first year when the supplier-customer relationship is initiated and call that firm the matched customer firm. We then follow the same matched customer firm until the supplier-customer relationship is terminated. To examine whether the positive leverage relationship is due to industry-specific shocks, we regress supplier leverage on matched customer leverage, and report the results for market leverage in Column (1)-(2) of Panel A of Table 3.6. The results show that while the coefficients on the matched customer leverage are still positive, they are statistically and economically insignificant.

Next we follow the same procedure to construct matched suppliers, and then regress matched supplier leverage on *Customer Leverage*. We report the results for market leverage in Column (3)-(4) of Panel A. Again, the effects of customer leverage on matched supplier leverage are very small and statistically insignificant. We also report similar results for book leverage in Panel B of Table 3.6. In unreported results, we also regress matched supplier leverage on matched customer leverage, and the coefficients on matched customer leverage are even smaller and statistically insignificant. To assure robustness, we also match customers and suppliers with different

[5]In unreported results, we also split the sample according to the geographical distance between the supplier and the customer and find that the positive leverage relationship remains on the subsample in which the distance between the supplier and the customer is above the sample median.

sets of firm characteristics, one characteristic at a time and combinations of different characteristics, the results are similar to those in Table 3.6.

Instrumental Variable Regressions

All OLS results above are subject to the obvious concern that customer leverage may be endogenous. If the supplier's leverage is affected by its customer's leverage, it is natural to expect that the customer's leverage is also affected by its supplier's leverage. This endogeneity problem also arises if some unobserved common factors, other than the local and industry-specific shocks documented above, simultaneously affect supplier leverage and customer leverage. For example, a positive shock to the customer's output market may create investment opportunities for both the supplier and the customer. In response to such an increase in investment opportunities, the supplier and the customer may decrease their leverages simultaneously. Therefore, a positive leverage relationship from the OLS regression may be biased if the included control variable *Market-to-Book* measures investment opportunities with error (for example, Erickson and Whited [2000]).

In this subsection, we use the instrumental variable approach to address the endogeneity problem. A valid instrument has to satisfy both the relevance and exclusion conditions. In our context, the relevance and exclusions conditions imply that the instrument affects customer leverage and affects supplier leverage *only* through customer leverage. We follow Leary and Roberts [2014] and use the customer firm's idiosyncratic return as an instrument for *Customer Leverage.* The *Idiosyncratic Return* is the five year monthly rolling window regression residual of the customer firm's stock return on six common risk factors. In addition to the five commonly used factors, namely market excess return ($R_M - R_f$), the small minus big portfolio return (SMB), the high minus low portfolio return (HML), the momentum portfolio return (MOM), and the industry portfolio return ($R_{ind} - R_f$), we also include the weighted average return of all supplying industries ($R_{sind} - R_f$) of the customer industry as an additional factor to mitigate the contagion effect along the supply chain. We follow the same procedure as in Leary and Roberts [2014] to construct the instrument. As argued by Leary and Roberts [2014], the customer's *Idiosyncratic Return* is correlated with *Customer Leverage*, but is unlikely to directly affect supplier leverage.

While it is impossible to test whether *Idiosyncratic Return* is truly exogenous, we follow Leary and Roberts [2014] and run diagnostic tests by regressing *Idiosyncratic Return* on a wide range of supplier variables, which include *Firm Size*, *Market-to-Book*, *Profitability*, *Tangibility*, *R & D*, and *Supplier Idiosyncratic Return*. We also include year fixed effects and industry fixed effects in the regression. Unreported results show that none of the supplier variables is statistically or economically significant, and the F-test of the overall significance also fails to reject the null hypothesis. While these results cannot ensure the validity of the instrument, these results show that the instrument does not contain no information about the supplier's commonly known capital structure determinants.

We then use the two-stage least squares to estimate the leverage relationship using *Idiosyncratic Return* as the instrument. In unreported first stage regressions, the coefficients on *Idiosyncratic Return* are all negative and statistically significant. We report the second stage regression results in Table 3.7, with Columns (1) and (2) for market leverage and Columns (3) and (4) for book leverage. In all specifications, the coefficients on customer leverage remain positive and statistically significant. In fact, the magnitudes are much larger than those from the OLS regressions.

Other Robustness tests

To mitigate the concern of indirect effects on suppliers' leverage, we include additional capital structure determinants previously identified in the literature into the leverage regressions. The additional capital structure determinants are capital investment (capx/at), Graham' marginal tax rate, an indicator of dividend payment, Altman' Z-score, selling expense (xsga/sale), and the price-cost margin. We report the instrumental variable estimation results for market leverage in Column (1) and (2) of Panel A of Table 3.8, and the instruments used is the *Idiosyncratic Return*. The results show that these additional controls have very small effects on the leverage relationship, and our results still hold.

We then exclude supplier-customer pairs which use the same underwriter for their public debt and equity issuances. Common underwriters may give similar advice to the customer and the supplier, which can lead to the positive leverage relationship. To mitigate this concern, we use the SDC database to identify lead underwriters for public debt and equity issuances. We also follow Leary and Roberts [2014] and assume that firms use the same lead underwriter each year until either the end of the sample or until the firm uses a different lead underwriter. We then exclude all supplier-customer firm-year observations in which the supplier and the customer use the same underwriters, and run the instrumental variable estimation using these three instruments. We report the results for market leverage with and without firm fixed effects in Column (3) and (4) of Panel A, and the results show that the inclusion (or exclusion) of the supplier-customer pairs with a common underwriter has a negligible effect on the leverage relationship.

Finally, we exclude supplier-customer pairs who are joint ventures or strategic alliances. It can be argued that joint ventures or strategic alliances may have correlated investment and financing policies, which can lead to the positive leverage relationship. To mitigate this concern, we also use the SDC database to identify supplier-customer pairs who are joint ventures or strategic alliances, and we then exclude these firm pairs from our sample. We report the instrumental variable estimations results for market leverage with and without firm fixed effects in Column (5) and (6), and the results show that the inclusion (or exclusion) of joint ventures and strategic alliances has a negligible effect on the leverage relationship.

We conduct the following robust tests to insure that our results are robust to different sample periods and different sampling methods.[6] We first conduct all tests above on sub-samples before 1997 and after 1997, which correspond to FAS 14 and SFAS 131, where the customer disclosure requirements differ. We find that our results hold for both sub-samples. Then, we include only the largest customer of the firm if the firm reports multiple customers, and our results still hold. Also, we exclude all retail firms that are reported as customers by any suppliers in the sample, and our results still hold.

Overall, the positive leverage relationship survives a battery of specifications and robustness tests. Our results support both the bargaining theory and the relation-specific theory of capital structure.

3.6 Conclusion

This paper studies the leverage relationship between customers and suppliers along the supply chain. We find that a supplier's leverage is positively associated with its customer's leverage. Consistent with the bargaining theory, we find that the positive relationship is stronger when the customer firms have more *ex-ante* bargaining power, and, consistent with the relation-specific investment theory, we find that the positive relationship is weaker when relation-specific investments are more important to the supply chain. Our paper suggests a dynamic relationship between suppliers and customers' leverage ratios. Also, our paper implies that firms may increase their leverage ratio to bargain with other stakeholders.

[6] To save space, we present the results below without tables.

Table 3.1 Summary Statistics

This table reports summary statistics for the variables used in this study. The sample period is from 1976 to 2009. *Market Leverage* is long-term debt divided by the sum market value of common equity and book value of the total liability. *Book Leverage* is long-term debt divided by book value of assets. The *Industry Herfindahl Index* is the Herfindahl index based on all Compustat firms in the 4-digit SIC industries. *Firm Size* is the log of book assets. *Profitability* is net operating income divided by total assets. *Tangibility* is net property, plant, and equipment divided by total assets. *Market-to-Book* is the market value of total assets to total book assets. *R & D Intensity* is R & D expense divided by total assets.

Panel A. Firm Summary Statistics

Variable	Mean	Median	Minimum	Maximum	Std dev.
Market Leverage	0.229	0.145	0.000	1.016	0.247
Book Leverage	0.262	0.205	0.000	2.248	0.279
Firm Size	4.505	4.361	0.000	10.587	2.141
Profitability	0.039	0.109	-2.502	0.554	0.279
Tangibility	0.275	0.207	0.000	0.931	0.230
Market-to-Book	1.839	1.167	0.147	42.055	2.173
R & D Intensity	0.012	0.000	0.000	1.067	0.059
Price-Cost Margin	0.232	0.335	-14.164	2.260	0.887
Industry Herfindahl Index	0.228	0.176	0.033	1	0.175
Median Industry R & D	0.047	0.008	0.000	0.478	0.067

Panel B. Customer Firm Summary Statistics

Variable	Mean	Median	Minimum	Maximum	Std dev.
Market Leverage	0.269	0.213	0.000	1.100	0.227
Book Leverage	0.245	0.236	0.000	0.793	0.150
Firm Size	9.498	9.796	3.100	13.590	1.807
Profitability	0.151	0.152	-1.317	4.084	0.104
Tangibility	0.325	0.297	0.000	0.943	0.203
Market-to-Book	1.533	1.074	0.068	39.425	1.955
R & D Intensity	0.036	0.000	0.000	1.335	0.053
Price-Cost Margin	0.351	0.316	-0.502	0.945	0.198
Industry Herfindahl Index	0.264	0.203	0.014	1	0.215
Median Industry R & D	0.031	0.000	0.000	0.477	0.055

Table 3.2 Ordinary Least Square Leverage Regressions

This table reports regression results of leverage on customer leverage and supplier firm controls. Panel A reports the results for market leverage regressions, and Panel B reports results for book leverage regressions. Standard errors clustered by customer-year are in parentheses. The sample period is 1976-2009. *Market Leverage* is total debt divided by the total market value. *Book Leverage* is total debt divided by book value of assets. *Firm Size* is the log of book assets. *Profitability* is net operating income divided by total assets. *Tangibility* is net property, plant, and equipment divided by total assets. *Market-to-Book* is the market value of total assets to total book assets. *R & D Intensity* is R & D expense divided by total assets. The symbols ***, ** and ** indicate significance levels at the 1%, 5%, and 10% levels.

Panel A. Market Leverage

	(1)	(2)	(3)	(4)	(5)
Customer Leverage	0.062***	0.043***	0.031***	0.029***	0.022**
	(0.019)	(0.013)	(0.008)	(0.008)	(0.010)
Firm Size	0.017***	0.014***	0.013***	0.014***	0.014***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
Market-to-Book	-0.011***	-0.009***	-0.009***	-0.012***	-0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Profitability	-0.081***	-0.080***	-0.082***	-0.083***	-0.075***
	(0.014)	(0.013)	(0.013)	(0.014)	(0.012)
Tangibility	0.264***	0.226***	0.223***	0.214***	0.198***
	(0.027)	(0.027)	(0.029)	(0.029)	(0.032)
R&D Intensity	-0.095***	-0.063***	-0.040**	-0.036**	-0.041**
	(0.033)	(0.024)	(0.017)	(0.016)	(0.018)
Constant	0.135**	0.112*	-0.097	-0.128	-0.112
	(0.061)	(0.063)	(0.089)	(0.121)	(0.097)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects		Yes	Yes	Yes	Yes
Customer Industry Fixed Effects			Yes	Yes	Yes
Customer Control			Yes	Yes	Yes
Firm Fixed Effects				Yes	
Pair Fixed Effects					Yes
Observations	10,388	10,388	8,604	8,604	8,604
R-squared	0.198	0.249	0.312	0.072	0.056

Panel B. Book Leverage

	(1)	(2)	(3)	(4)	(5)
*C*ustomer Leverage	0.053**	0.043**	0.042***	0.023***	0.044**
	(0.025)	(0.020)	(0.019)	(0.009)	(0.023)
*I*ndustry Median Leverage	0.599***	0.688***	0.557***	0.515***	0.505***
	(0.091)	(0.070)	(0.085)	(0.066)	(0.096)
*F*irm Size	-0.001	-0.004	-0.000	0.047***	0.064***
	(0.006)	(0.006)	(0.006)	(0.004)	(0.008)
*M*arket-to-Book	-0.003*	-0.002*	-0.003*	-0.001**	-0.000
	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)
*P*rofitability	-0.433**	-0.431**	-0.478**	-0.088***	-0.077***
	(0.171)	(0.175)	(0.200)	(0.017)	(0.027)
*T*angibility	0.201***	0.355***	0.219***	0.195***	0.177***
	(0.036)	(0.073)	(0.038)	(0.024)	(0.046)
R & D Intensity	-0.223	-0.244	-0.289	-0.047**	0.000
	(0.244)	(0.265)	(0.285)	(0.024)	(0.038)
Constant	0.105***	0.047	0.115***	0.104***	0.032
	(0.031)	(0.072)	(0.030)	(0.025)	(0.028)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects		Yes	Yes	Yes	Yes
Customer Industry Fixed Effects			Yes	Yes	Yes
Customer Control			Yes	Yes	Yes
Firm Fixed Effects				Yes	
Pair Fixed Effects					Yes
Observations	12,261	12,261	8,774	8,774	8,774
R-squared	0.080	0.126	0.198	0.062	0.053

Table 3.3 The Effect of Customer Bargaining Power on the Leverage Relationship

This table presents instrumental variable estimations for regressions of supplier leverage on customer leverage and customer leverage interacted with indicators of customer bargaining power. Standard errors clustered by customer-year are in parentheses. The sample period is 1976-2009. The indicator variables for customer bargaining power are: *Large* = 1 if the log assets of the customer firm is greater than two times the annual industry median log assets, and *Large* = 0 otherwise; *Power* = 1 if the price-cost margin of the customer firm is greater than the annual industry median price-cost margin, and *Power* = 0 otherwise; *Concentration* = 1 if the customer firm's industry Herfindahl index is higher than the annual median Herfindahl index of the sample, and *Concentration* = 0 otherwise. The instruments used are the *Idiosyncratic Return* and its interactions with *Large*, *Power*, and *Concentration*, respectively. To save space, we only report the coefficient estimates of the indicator variables and the interaction variables. *Market Leverage* is total debt divided by the total market value. *Book Leverage* is total debt divided by book value of assets. *Firm Size* is the log of book assets. *Profitability* is net operating income divided by total assets. *Tangibility* is net property, plant, and equipment divided by total assets. *Market-to-Book* is the market value of total assets to total book assets. *R & D Intensity* is R & D expense divided by total assets. The symbols ***, ** and * indicate significance levels at the 1%, 5%, and 10% levels.

Panel A. Market Leverage

	(1)	(2)	(3)	(4)	(5)	(6)
Customer Leverage	0.077**	0.063***	0.045	0.030	0.102***	0.056
	(0.024)	(0.033)	(0.038)	(0.051)	(0.033)	(0.048)
*Customer Leverage * Large*	0.085***	0.046**				
	(0.015)	(0.020)				
Large	-0.010	-0.005				
	(0.014)	(0.027)				
*Customer Leverage * Power*			0.088**	0.045**		
			(0.019)	(0.020)		
Power			-0.008*	-0.006		
			(0.012)	(0.011)		
*Customer Leverage * Concentration*					0.045***	0.040**
					(0.012)	(0.021)
Concentration					0.015	-0.002
					(0.012)	(0.015)
Constant	0.016		0.020		-0.002	
	(0.019)		(0.020)		(0.018)	
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Customer Controls		Yes		Yes		Yes
Customer Industry Fixed Effects		Yes		Yes		Yes
Observations	10,388	8,604	9,547	7,623	10,388	8,604
R-squared	0.237	0.294	0.236	0.298	0.237	0.298

Panel B. Book Leverage

	(1)	(2)	(3)	(4)	(5)	(6)
Customer Leverage	0.062***	0.022	0.109**	0.092	0.136	0.060
	(0.016)	(0.035)	(0.048)	(0.102)	(0.093)	(0.117)
*Customer Leverage * Large*	0.051***	0.062***				
	(0.015)	(0.023)				
Large	-0.028	0.083				
	(0.043)	(0.092)				
*Customer Leverage * Power*			0.064**	0.088**		
			(0.030)	(0.043)		
Power			-0.003	0.154		
			(0.028)	(0.136)		
*Customer Leverage * Concentration*					0.132***	0.069**
					(0.022)	(0.031)
Concentration					-0.055	-0.031
					(0.037)	(0.040)
Constant	0.110**		0.089*		0.079	
	(0.043)		(0.047)		(0.050)	
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Customer Controls		Yes		Yes		Yes
Customer Industry Fixed Effects		Yes		Yes		Yes
Observations	12,261	8,774	11,683	7,957	12,261	8,774
R-squared	0.080	0.128	0.079	0.129	0.075	0.130

Table 3.4 The Effect of Relation-Specific Investments on the Leverage Relationship

This table presents instrumental variable estimations for regressions of supplier leverage on customer leverage and customer leverage interacted with indicators of relation-specific investments. Standard errors clustered by customer-year are in parentheses. The sample period is 1976-2009. The indicator variables for the importance of relation-specific investments are: *Relation* = 1 if the customer firm's industry median R & D intensity is positive, and *Relation* = 0 otherwise; *Durable* = 1 if the customer firm is in durable goods industries, and *Durable* = 0 otherwise. The instruments used are *Idiosyncratic Return* and its interactions with *Relation* and *Durable*, respectively. *Market Leverage* is total debt divided by the total market value. *Book Leverage* is total debt divided by book value of assets. *Firm Size* is the log of book assets. *Profitability* is net operating income divided by total assets. *Tangibility* is net property, plant, and equipment divided by total assets. *Market-to-Book* is the market value of total assets to total book assets. *R & D Intensity* is R & D expense divided by total assets. To save space, we only report the coefficient estimates of the indicator variables and the interaction variables. The symbols ***, ** and * indicate significance levels at the 1%, 5%, and 10% levels.

Panel A. Market Leverage

	(1)	(2)	(3)	(4)
Customer Leverage	0.065***	0.066**	0.078**	0.058**
	(0.015)	(0.032)	(0.035)	(0.026)
*Customer Leverage * Relation*	-0.026**	-0.020		
	(0.011)	(0.026)		
Relation	-0.039**	-0.103*		
	(0.017)	(0.057)		
*Customer Leverage * Durable*			-0.045***	-0.068**
			(0.012)	(0.032)
Durable			0.006	
			(0.013)	
Constant	0.036*		0.005	
	(0.022)		(0.018)	
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Customer Controls		Yes		Yes
Customer Industry Fixed Effects		Yes		Yes
Observations	10,388	8,604	10,388	8,604
R-squared	0.240	0.297	0.236	0.297

Panel B. Book Leverage

	(1)	(2)	(3)	(4)
Customer Leverage	0.145***	0.280***	0.103***	0.281***
	(0.031)	(0.054)	(0.021)	(0.065)
*Customer Leverage * Relation*	-0.101***	-0.368***		
	(0.016)	(0.051)		
Relation	-0.033	0.034		
	(0.045)	(0.165)		
Customer Leverage Durable*			-0.103***	-0.443***
			(0.016)	(0.055)
Durable			-0.024	
			(0.034)	
Constant	0.109**		0.099*	
	(0.053)		(0.053)	
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Customer Controls		Yes		Yes
Customer Industry Fixed Effects		Yes		Yes
Observations	12,261	8,774	12,261	8,774
R-squared	0.080	0.129	0.079	0.129

Table 3.5 Local Shocks and the Leverage Relationship

This table reports regression results of leverage on customer leverage and supplier firm controls on two sub-samples in which the supplier and the customer are in the same states or in different states. Panel A reports the results for market leverage regressions, and Panel B reports results for book leverage regressions. Standard errors clustered by customer-year are in parentheses. The sample period is 1976-2009. *Market Leverage* is total debt divided by the total market value. *Book Leverage* is total debt divided by book value of assets. *Firm Size* is the log of book assets. *Profitability* is net operating income divided by total assets. *Tangibility* is net property, plant, and equipment divided by total assets. *Market-to-Book* is the market value of total assets to total book assets. *R & D Intensity* is R & D expense divided by total assets. The symbols ***, ** and ** indicate significance levels at the 1%, 5%, and 10% levels.

Panel A. Market Leverage

	Same State		Different States	
	(1)	(2)	(3)	(4)
Customer Leverage	0.047***	0.036***	0.039**	0.028**
	(0.023)	(0.015)	(0.009)	(0.013)
Industry Median Leverage	0.468***	0.369***	0.565***	0.527***
	(0.064)	(0.077)	(0.026)	(0.031)
Firm Size	0.018***	0.020***	0.011***	0.012***
	(0.003)	(0.005)	(0.001)	(0.001)
Market-to-Book	-0.017***	-0.014***	-0.008***	-0.011***
	(0.002)	(0.003)	(0.002)	(0.001)
Profitability	-0.159***	-0.164***	-0.068***	-0.072***
	(0.027)	(0.031)	(0.010)	(0.010)
Tangibility	0.279***	0.301***	0.164***	0.158***
	(0.041)	(0.055)	(0.017)	(0.019)
R & D Intensity	0.000	0.039	-0.035**	-0.021*
	(0.041)	(0.046)	(0.016)	(0.012)
Constant	0.125***	0.013	-0.052	-0.216**
	(0.033)	(0.098)	(0.065)	(0.096)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Customer Industry Fixed Effects		Yes		Yes
Customer Controls		Yes		Yes
Observations	1,338	1,154	9,050	7,450
R-squared	0.407	0.478	0.294	0.343

Panel B. Book Leverage

	Same State		Different States	
	(1)	(2)	(3)	(4)
Customer Leverage	0.045**	0.028***	0.040**	0.020**
	(0.058)	(0.015)	(0.021)	(0.010)
Industry Median Leverage	0.944***	0.820***	0.817***	0.750***
	(0.249)	(0.243)	(0.060)	(0.062)
Firm Size	0.012*	-0.008	0.002	0.001
	(0.007)	(0.008)	(0.003)	(0.003)
Market-to-Book	-0.006	-0.001	0.006*	0.005
	(0.005)	(0.005)	(0.003)	(0.005)
Profitability	-0.291***	-0.294*	-0.228***	-0.241**
	(0.110)	(0.156)	(0.066)	(0.101)
Tangibility	0.303***	0.211*	0.280***	0.257***
	(0.051)	(0.110)	(0.046)	(0.060)
R & D Intensity	0.602	0.220**	0.386***	0.262***
	(0.370)	(0.110)	(0.101)	(0.081)
Constant	-0.055	0.077	-0.104**	-0.304**
	(0.091)	(0.118)	(0.047)	(0.126)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Customer Industry Fixed Effects		Yes		Yes
Customer Controls		Yes		Yes
Observations	1,599	1,178	10,662	7,596
R-squared	0.235	0.296	0.182	0.212

Table 3.6 Industry-Specific Shocks and the Leverage Relationship

This table reports the leverage regression results with matched customers and matched suppliers. The first two columns report regressions results of supplier leverage on matched customer leverage, and the last two columns report regression results of matched supplier leverage on customer leverage. Panel A reports the results for market leverage regressions, and Panel B reports results for book leverage regressions. Standard errors clustered by customer-year are in parentheses. The sample period is 1976-2009. *Market Leverage* is total debt divided by the total market value. *Book Leverage* is total debt divided by book value of assets. *Firm Size* is the log of book assets. *Profitability* is net operating income divided by total assets. *Tangibility* is net property, plant, and equipment divided by total assets. *Market-to-Book* is the market value of total assets to total book assets. *R & D Intensity* is R & D expense divided by total assets. The symbols ***, ** and ** indicate significance levels at the 1%, 5%, and 10% levels.

Panel A. Market Leverage

	Matched Customer		Matched Supplier	
	(1)	(2)	(3)	(4)
			0.020**	0.006
			(0.008)	(0.011)
Customer Leverage	0.020*	0.009		
	(0.010)	(0.011)		
Matched Customer Leverage	0.649***	0.656***	0.570***	0.559***
	(0.027)	(0.029)	(0.021)	(0.025)
Industry Median Leverage	0.009***	0.010***	-0.001	-0.001*
	(0.001)	(0.001)	(0.001)	(0.001)
Size	-0.001**	-0.001**	-0.000	-0.000
	(0.001)	(0.001)	(0.000)	(0.000)
Market-to-Book	-0.093***	-0.091***	-0.006***	-0.006**
	(0.012)	(0.014)	(0.001)	(0.003)
Profitability	0.216***	0.218***	0.207***	0.211***
	(0.016)	(0.017)	(0.013)	(0.015)
Tangibility	-0.143***	-0.125***	-0.043***	-0.043***
	(0.020)	(0.021)	(0.006)	(0.009)
R&D Intensity	0.027	0.024	0.032	0.027
	(0.036)	(0.040)	(0.080)	(0.096)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Customer Industry Fixed Effects		Yes		Yes
Customer Controls		Yes		Yes
Observations	9,695	8,125	9,496	8,254
R-squared	0.290	0.302	0.216	0.256

Panel B. Book Leverage

	Matched Customer		Matched Supplier	
	(1)	(2)	(3)	(4)
			0.000	0.000
			(0.000)	(0.000)
Customer Leverage	-0.000	0.000		
	(0.000)	(0.000)		
Matched Customer Leverage	0.629***	0.648***	0.507***	0.514***
	(0.065)	(0.074)	(0.058)	(0.061)
Industry Median Leverage	-0.002	-0.002	-0.002	-0.002
	(0.003)	(0.004)	(0.002)	(0.003)
Size	-0.002**	-0.002**	-0.002**	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Market-to-Book	-0.249***	-0.233***	-0.154**	-0.148**
	(0.043)	(0.047)	(0.072)	(0.068)
Profitability	0.278***	0.274***	0.213***	0.223***
	(0.038)	(0.035)	(0.042)	(0.034)
Tangibility	0.088	0.149	0.063	0.088
	(0.138)	(0.149)	(0.125)	(0.134)
R&D Intensity	0.047	0.076**	0.031	0.065
	(0.034)	(0.038)	(0.025)	(0.035)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Customer Industry Fixed Effects		Yes		Yes
Customer Controls		Yes		Yes
Observations	11,062	8,363	10,797	8,376
R-squared	0.115	0.166	0.112	0.162

Table 3.7 Instrumental Variable Regressions

This table reports the second stage regression results of the instrumental variable estimation of the leverage equations with the customer idiosyncratic return as the instrument. Columns (1) and (2) report the results of market leverage regressions, and Columns (3) and (4) report results for book leverage regressions. Standard errors clustered by customer-year are in parentheses. The sample period is 1976-2009. *Market Leverage* is total debt divided by the total market value. *Book Leverage* is total debt divided by book value of assets. *Firm Size* is the log of book assets. *Profitability* is net operating income divided by total assets. *Tangibility* is net property, plant, and equipment divided by total assets. *Market-to-Book* is the market value of total assets to total book assets. *R & D Intensity* is R & D expense divided by total assets. The symbols ***, ** and ** indicate significance levels at the 1%, 5%, and 10% levels.

Dependent Variables	Market Leverage		Book Leverage	
	(1)	(2)	(3)	(4)
Customer Leverage	0.125***	0.249***	0.148*	0.127**
	(0.035)	(0.076)	(0.081)	(0.061)
Medium Industry Leverage	0.671***	0.489***	0.537***	0.385***
	(0.032)	(0.034)	(0.092)	(0.061)
Firm Size	0.012***	0.052***	0.000	-0.047
	(0.002)	(0.005)	(0.005)	(0.032)
Market-to-Book	-0.002**	-0.000	-0.003**	-0.001
	(0.001)	(0.000)	(0.001)	(0.001)
Profitability	-0.109***	-0.081***	-0.478**	-0.425
	(0.019)	(0.024)	(0.196)	(0.278)
Tangibility	0.103***	0.178***	0.204***	0.434**
	(0.020)	(0.033)	(0.037)	(0.169)
R&D Intensity	-0.166***	-0.017	-0.284	-0.409
	(0.034)	(0.033)	(0.286)	(0.330)
Constant	0.002	0.012	0.084***	0.065***
	(0.018)	(0.024)	(0.022)	(0.018)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Customer Industry Fixed Effects		Yes		Yes
Customer Controls		Yes		Yes
Observations	9,851	7,532	10,124	7,615
R-squared	0.235	0.288	0.123	0.195

Table 3.8 Other Alternative Explanations

This table presents tests to rule out other alternative explanations. The sample period is 1976-2009. Standard errors clustered by customer-year are in parentheses. Column (1) and (2) report leverage equation regression results with additional supplier controls; Column (3) and (4) report regression results excluding supplier-customer pairs which use same lead underwriters. Column (5) and (6) report results excluding supplier-customer pairs who are joint ventures or strategic Alliances. All results are estimated using *Idiosyncratic Return* as the instrument. The variables are: *Market Leverage*, long-term debt divided by the sum market value of common equity and book value of total liability, *Book Leverage*, long-term debt divided by book value of assets, *Firm Size*, the log of book assets, *Profitability*, net operating income divided by total assets, *Tangibility*, net property, plant, and equipment divided by total assets, *Market-to-Book*, the market value of total assets to total book assets and *R & D Intensity*, R & D expense divided by total asset. Additional controls include: investment (capx/at), Graham' marginal tax rate, an indicator of dividend payment, Altman' Z-score, selling expense (xsga/sale), and the price-cost margin. The symbols ***, ** and * indicate significance levels at the 1%, 5%, and 10% levels.

Panel A. Market Leverage

	(1)	(2)	(3)	(4)	(5)	(6)
Customer Leverage	0.125***	0.064**	0.123***	0.083***	0.133***	0.104***
	(0.024)	(0.031)	(0.025)	(0.015)	(0.016)	(0.023)
Industry Median Leverage	0.654***	0.478***	0.613***	0.512***	0.596***	0.495***
	(0.029)	(0.033)	(0.029)	(0.033)	(0.029)	(0.034)
Firm Size	0.012***	0.044***	0.012***	0.029***	0.013***	0.032***
	(0.002)	(0.004)	(0.002)	(0.006)	(0.002)	(0.006)
Market-to-Book	-0.002	-0.001**	-0.002***	-0.002***	-0.002***	-0.000
	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Profitability	-0.092***	-0.082***	-0.105***	-0.083***	-0.104***	-0.081***
	(0.008)	(0.011)	(0.015)	(0.027)	(0.009)	(0.025)
Tangibility	0.115***	0.193***	0.112***	0.178***	0.107***	0.184***
	(0.020)	(0.025)	(0.019)	(0.029)	(0.012)	(0.031)
R & D Intensity	-0.174***	-0.022	-0.133***	-0.023	-0.115***	-0.025
	(0.015)	(0.021)	(0.013)	(0.015)	(0.013)	(0.015)
Constant	0.005		0.012		0.009	
	(0.015)		(0.013)		(0.024)	
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Customer Industry Fixed Effects		Yes		Yes		Yes
Customer Controls		Yes		Yes		Yes
Additional Supplier Controls	Yes	Yes				
Observations	9,534	7,243	8,432	6,178	8,518	6,048
R-squared	0.263	0.294	0.235	0.288	0.265	0.291

Panel B. Book Leverage

	(1)	(2)	(3)	(4)	(5)	(6)
Customer Leverage	0.133***	0.102***	0.164***	0.104***	0.126***	0.113***
	(0.023)	(0.034)	(0.023)	(0.033)	(0.026)	(0.034)
Industry Median Leverage	0.568***	0.412***	0.519***	0.402***	0.534***	0.405***
	(0.092)	(0.102)	(0.089)	(0.094)	(0.090)	(0.101)
Firm Size	-0.002	-0.061	-0.001	-0.059	-0.002	-0.058
	(0.005)	(0.045)	(0.005)	(0.041)	(0.006)	(0.040)
Market-to-Book	-0.003**	-0.001	-0.002**	-0.001	-0.003**	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Profitability	-0.415**	-0.329	-0.467**	-0.375	-0.458**	-0.398
	(0.203)	(0.288)	(0.212)	(0.312)	(0.228)	(0.336)
Tangibility	0.197***	0.415***	0.201***	0.436***	0.203***	0.421**
	(0.036)	(0.123)	(0.037)	(0.148)	(0.038)	(0.197)
R & D Intensity	-0.213	-0.298	-0.224	-0.315	-0.206	-0.378
	(0.253)	(0.342)	(0.237)	(0.278)	(0.246)	(0.345)
Constant	0.076*		0.085*		0.098**	
	(0.040)		(0.042)		(0.043)	
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Customer Industry Fixed Effects		Yes		Yes		Yes
Customer Controls		Yes		Yes		Yes
Additional Supplier Controls	Yes	Yes				
Observations	10,278	7,584	10,019	6,853	9,735	6,745
R-squared	0.089	0.136	0.079	0.128	0.078	0.127

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Appendix A
Definitions of variables for the first chapter

QE 1 is a dummy variable that equals 1 if a bond was issued between March 2009 (when the Fed launched the Treasury purchase programs) and October 2009.

QE 2 is a dummy variable that equals 1 if a bond was issued between Nov. 2010 and June 2011.

FG/OT is a dummy variable that equals 1 if a bond was issued between August 2011 and December 2012. I do not distinguish between the FG period and the OT period because the two periods largely overlapped.

dd1_at is the fraction of long-term debt maturing in 1 year (dd1/at). Data are from COMPUSTAT annual file.

Roll is a bond liquidity measure for individual firms. The variable is constructed following Bao et al. [2011] using the equation $Roll = 2\sqrt{-Cov(\Delta P_{it}, \Delta P_{it-1})}$. Roll is estimated using all bond transactions within the last month for each firm. If several bonds exist for a firm, the median value is used.

CDS are single-name 5-year CDS spreads. Data are from Markit Inc.

Baa-AAA spread is calculated using Moodys' Baa and AAA index yields.

on-off is the difference between off-the-run and on-the-run 10-year Treasury rates. Both are downloaded from the Citi Yield Book. This variable is used to proxy the market liquidity.

T 10 is the interest rate on 10-year constant maturity Treasuries. Data are from H.15.

VIX is the measure of market expectations of near-term volatilities conveyed by S&P 500 stock index option prices. Data are downloaded from CBOE.

β_{Baa_AAA}**,** β_{on_off}**,** $\beta_{T\ 10}$**, and** β_{VIX} are sensitivities of log 2-day changes in individual CDS spreads to log changes in Baa-AAA spreads, on-off run spreads, 10 year Treasury rates, and VIX, respectively. The βs are estimated using $\Delta CDS_{it} = \alpha + \beta_1 \Delta Baa\_AAA_t + \beta_2 \Delta on\_off_t + \beta_3 \Delta VIX_t + \beta_4 \Delta T10_t + \eta \Delta mklev_{it} + \lambda \Delta vol_{it} + \varepsilon_{i,t}$. For each day, βs are estimated using data in the last 180 days.

imp_vol is the implied volatility calculated as (call implied volatility+put implied volatility)/2. Only contracts that mature in the next month and have delta closest to 0.5/-0.5 are used. Data are from OptionMetrices.

Treasury maturity is the log of the weighted average maturity of outstanding Treasury principal and coupon payments. Data are from Mergent FISD and TreasuryDirect.

Preferred-habitat is the fraction of preferred-habitat investors, including property-casualty insurance companies, life insurance companies, private pension funds, state and local government employee retirement funds, and federal government retirement funds, in the Treasury and corporate bond market. Data are from Flow of Fund.

trend is calculated as (year-1989)*12 + month, following Custódio et al. [2012]

term spreads are calculated as differences between interest rates on 10-year and 1-year constant maturity Treasuries. Data are from H.15.

Recession is the NBER recession dummy.

age is the age of a firm proxied by the number of years the company is included in Compustat.

log asset is the log of asset (atq). Data are from Compustat quarterly file.

stock return is the stock return in the previous year. Data are from CRSP monthly file.

IG is a dummy variable that equals 1 if the firm is rated BBB- (Baa3) or above.

rating is an ordinal variable, where 1 means credit rating of AAA class, 2 means credit rating of AA class, 3 means credit rating of A class, 4 means credit rating of BBB class, 5 means credit rating of BB class, 6 means credit rating of B class, 7 means credit rating of C class, and 8 means non-rated.

mke is the market value of equity. When studying CDS spreads, mke is prcc*csho calculated on a daily basis; when studying debt maturity, mke is calculated as prccfq*cshoq. Data are from CRSP and Compustat quarterly file.

bke is the book value of equity calculated as seq; if not available, (ceqq+pstkq); if not available, (atq-ltq+txditcq-pstkrvq); if not available, pstklq; and if not available, pstkq. Data are from COMPUSTAT quarterly file.

mkat is the market value of total assets calculated as (mke+atq-bke). Data are from COMPUSTAT quarterly file.

bklev is the book leverage ratio calculated as (dlcq+ dlttq) /atq. Data are from COMPUSTAT quarterly file.

mklev is the market leverage calculated as (dlcq + dlttq) / mkat. Data are from COMPUSTAT quarterly file and CRSP.

mk2bk is the market-to-book ratio calculated as mkat/atq. Data are from COMPUSTAT quarterly file and CRSP.

profit is the operating income before depreciation over asset (oibdpq/atq). Data are from COMPUSTAT quarterly file.

asset maturity is the asset maturity calculated as (ppent/(act + ppent)* (ppent/dp)+ act/(act + ppent) * (act/cogs)). Data are from COMPUSTAT annual file.

rnd is the research and development calculated as xrdq/atq. Data are from COMPUSTAT quarterly file.

asset volatility is the asset volatility coefficient calculated as volatility(asset)/mean(asset) in past 8 quarters. Data are from COMPUSTAT quarterly file.

CP user equals 1 if the firm has an S&P short-term debt rating of A-1+, A-1, or A-2.

Fin segment equals 1 if the firm reports a business segment with an SIC code between 6000 and 6999 in the recent fiscal year.

Appendix B
UMP announcements

This appendix lists all UMP announcements between November 2008 and June 2012 studied in this paper.

QE 1 initiation and expanding announcements

QE 1_1 (11/25/2008) The initial LSAP announcement, in which the Fed announced that they would purchase up to $100 billion in agency debt, and up to $500 billion in agency MBS.

QE 1_2 (12/1/2008) Chairman Bernanke's speech, in which he stated that in order to "improve conditions in private credit markets", the Fed âĂIJcould purchase longer-term Treasury securitiesâĂęâĂİ.

QE 1_3 (12/16/2008) FOMC statement, which indicated that they were considering purchases of longer-term Treasury securities.

QE 1_4 (1/28/2009) FOMC statement, which indicated that the Fed stood ready to expand QE and buy Treasuries.

QE 1_5 (3/18/2009) FOMC statement, which announced the decision to purchase âĂIJup toâĂİ $300 billion of longer-term Treasury securities and an additional $750 and $100 billion in MBS and GSE debt, respectively.

QE 1 slowing/exiting announcements

QE 1 T_1 (8/12/2009) FOMC statement, which announced gradually slowing the pace of Treasury transactions and anticipated that the full amount will be purchased by the end of October.

QE 1 T_2 (9/23/2009) FOMC statement, which announced slowing the pace of agency MBS and agency debt purchases and anticipated that they would be executed by the end of the first quarter of 2010.

QE 1 T_3 (11/4/2009) FOMC statement, which stated that they would downsize the purchase of agency debt to around $175 billion.

QE 2 expanding announcements

QE 2_1 (8/10/2010) FOMC statement, which stated that they would reinvest principal payments from LSAPs

QE 2_2 (9/21/2010) FOMC statement, which indicated new stimulus by the Fed to promote economic recovery and price stability.

QE 2_3 (11/3/2010) FOMC statement, which announced a purchase of $600 billion in Treasuries.

QE 2 exiting announcements

QE 2 T (6/22/2011) FOMC statement, which announced completing its purchases of long-term Treasury securities by the end of the month and maintaining reinvesting principal payments.

Operation Twist announcements

OT 2011 (9/21/2011) FOMC statement, which announced that they would purchase $400 billion of Treasury securities with remaining maturities of 6 years to 30 years and to sell an equal amount of Treasury securities with remaining maturities of 3 years or less by the end of June 2012.

OT 2012 (6/20/2012) FOMC statement, which announced to continue the Operation Twist program through the end of 2012. This announcement extended the size of the OT to $600 billion in Treasuries.

Forward Guidance announcements

FG 2011 (8/9/2011) FOMC minutes, "Most members...agreed that stating a conditional expectation for the level of the federal funds rate through mid-2013".

FG 2012 (1/25/2012) FOMC minutes, "...[the Fed is] likely to warrant exceptionally low levels for the federal funds rate at least through late 2014."

Note: The selection of the announcement dates is based on FOMC statements and minute releases and the discussions in Krishnamurthy and Vissing-Jorgensen [2011] and Fawley and Neely [2013].

Appendix C
Other Robustness Check

Table C.1 Rollover Risk Exposures by Rating and Year

This table shows the number of firms with high/low rollover risk exposures by rating and year. High rollover risk is defined as having long-term debt maturing in one year over assets larger than 5%.

		AAA/AA	A	BBB	BB	B	CCC	Total
2005	dd1_at< .05	44	66	58	40	24	14	246
	dd1_at>= .05	9	10	12	8	8	2	49
2006	dd1_at< .05	38	62	52	46	29	14	241
	dd1_at>= .05	8	4	11	8	6	1	38
2007	dd1_at< .05	45	59	58	45	33	14	254
	dd1_at>= .05	5	9	13	6	9	2	44
2008	dd1_at< .05	46	65	65	42	34	11	263
	dd1_at>= .05	2	4	11	9	6	2	34
2009	dd1_at< .05	43	64	66	46	32	12	263
	dd1_at>= .05	6	4	8	4	5	1	28
2010	dd1_at< .05	44	57	68	44	31	13	257
	dd1_at>= .05	3	5	6	5	5	1	25
2011	dd1_at< .05	42	56	64	42	28	8	240
	dd1_at>= .05	3	7	10	7	6	3	36
2012	dd1_at< .05	35	44	56	35	23	7	200
	dd1_at>= .05	2	9	6	6	6	0	29

Table C.2 Rollover Risk and Changes in CDS Spreads

This table shows how rollover risk affects the sensitivity of changes in CDS spreads to changes in market condition indicators. In columns 2-6, rollover risk (RO) are proxied by long-term debt maturing in one year over asset (dd1_at), long-term debt maturing in one year over total long-term debt (dd1_lt), a dummy which equals 1 if long-term debt maturing in one year over total long-term debt is larger than 0.2 (ro_dummy1), a dummy which equals 1 if long-term debt maturing in one year over asset is larger than 0.05 (ro_dummy2), and bond liquidity measure (Roll), respectively. All changes are log changes. Control variables are defined in appendix 1. Standard errors in parentheses are corrected using the Newey West method allowing for 12 lags. $***p < 0.01, **p < 0.05, *p < 0.1$

ΔCDS	(1)	(2) RO: dd1_at	(3) RO: dd1_lt	(4) RO Dummy: dd1_lt>0.2	(5) RO Dummy: dd1_at>.05	(6) RO: Roll
RO *		0.505***	0.007	-0.006	0.011	0.055***
ΔBaa_aaa		(0.170)	(0.041)	(0.016)	(0.015)	(0.006)
RO*		0.023	0.008	0.003	0.002	0.002**
Δon_off		(0.030)	(0.007)	(0.003)	(0.003)	(0.001)
RO *		0.187***	-0.009	-0.008*	0.002	0.012***
Δvix		(0.047)	(0.011)	(0.004)	(0.004)	(0.002)
RO *		-0.589***	-0.076**	-0.026*	-0.030**	0.018***
$\Delta T10$		(0.143)	(0.036)	(0.014)	(0.012)	(0.004)
dd1_at		0.001				
		(0.004)				
dd1_lt			0.001*			
			(0.001)			
ro_dummy1				0.000		
				(0.000)		
ro_dummy2					0.001	
					(0.000)	
Roll						-0.000
						(0.000)
Δvol	0.020***	0.020***	0.020***	0.020***	0.020***	0.020***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\Delta mklev$	0.171***	0.173***	0.171***	0.171***	0.171***	0.202***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)
ΔBaa_aaa	0.318***	0.308***	0.318***	0.318***	0.316***	0.326***
	(0.005)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
Δon_off	0.012***	0.012***	0.012***	0.012***	0.012***	0.012***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\Delta T10$	-0.129***	-0.118***	-0.124***	-0.127***	-0.126***	-0.134***
	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
ΔVIX	0.062***	0.058***	0.063***	0.063***	0.062***	0.067***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
log asset	0.000**	0.000**	0.000*	0.000**	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
mk2bk	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
mklev	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
tangible	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
profit	0.000	0.000	0.000	0.000	0.000	-0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm-fixed	Y	Y	Y	Y	Y	Y
Observations	198,522	198,522	198,522	198,522	198,522	162,176
R-squared	0.105	0.106	0.105	0.105	0.105	0.117

Table C.3 The Determinants of Beta Sensitivities to Market Conditions

This table reports the determinants of beta sensitivities, controlling for the liquidity of CDS contracts. Using firm-year data, the following equation is estimated: $\beta_{k,i,t} = \alpha + \theta_k controls_{i,t-1} + \varepsilon_{i,t}$, where t is closest trading date to June 30th each year; k=1, 2, 3, and 4, represent Baa_AAA, on_off, VIX, and 10-year Treasury rates, respectively; $\beta_{k,i,t}$ are estimated within window [t-180, t-1] for each firm each year; $controls_{i,t-1}$ are firm characters from the latest annual report on December 31 of last calendar year. The liquidity of CDS contracts are controlled by the "CDX dummy" and "quote depth". "CDX dummy" equals one if the firm is a investment-grade CDX member in a year. "quote depth" is the median number of contributor prices used to build the composite price daily data in the estimation window. The higher the "quote depth", the more liquid the CDS contract. Industry fixed effects are controlled at the one-digit SIC level. Other variables are defined in the appendix. Four equations corresponding to these four beta sensitivities are estimated using *seemingly unrelated equations*. Standard errors are in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$

	β_{Baa_AAA}	β_{on_off}	β_{VIX}	$\beta_{T\ 10}$
Roll	-0.017**	0.002	-0.001	-0.009
	(0.008)	(0.002)	(0.003)	(0.010)
dd1_at	0.212	0.128*	0.150	0.009
	(0.291)	(0.072)	(0.098)	(0.357)
log asset	0.030***	-0.000	0.006*	-0.029**
	(0.010)	(0.002)	(0.003)	(0.012)
implied volatility	-0.075	-0.021	0.048**	-0.033
	(0.070)	(0.017)	(0.024)	(0.086)
mk2bk	0.008	0.001	-0.003	0.022
	(0.020)	(0.005)	(0.007)	(0.024)
mk leverage	0.055	0.013	-0.006	0.100
	(0.091)	(0.023)	(0.030)	(0.111)
tangibility	0.035	-0.008	0.007	-0.039
	(0.045)	(0.011)	(0.015)	(0.056)
profitability	0.017	-0.012	-0.014	-0.168
	(0.157)	(0.039)	(0.053)	(0.192)
distance to default	-0.010***	0.001*	-0.001	-0.002
	(0.003)	(0.001)	(0.001)	(0.004)
cp user	-0.050**	0.002	-0.006	-0.007
	(0.021)	(0.005)	(0.007)	(0.026)
financial segment	0.034	0.009	-0.025***	-0.011
	(0.024)	(0.006)	(0.008)	(0.029)
IG	0.239	-0.063	-0.126*	0.146
	(0.218)	(0.054)	(0.073)	(0.268)
CDX dummy	-0.017	-0.012**	0.030***	-0.108***
	(0.021)	(0.005)	(0.007)	(0.026)
quote depth	0.016***	-0.001	0.009***	0.001
	(0.003)	(0.001)	(0.001)	(0.003)
Constant	-0.075	0.121**	0.059	-0.168
	(0.238)	(0.059)	(0.080)	(0.292)
Rating Fixed	Y	Y	Y	Y
Year Fixed	Y	Y	Y	Y
Industry Fixed	Y	Y	Y	Y
Observations	1,690	1,690	1,690	1,690
R-squared	0.260	0.192	0.388	0.223

Table C.4 Robustness: The Impact of QE on Risk Premia

The table shows the impact of QE on risk premia using error-weighted β estimations as independent variables. The following equation is estimated:

$$\Delta CDS_{i,t} = \alpha + \sum \Delta\gamma_{k,j}\beta_{k,i,t}/\sigma_{k,i,t} * Event_j + \sum \theta_j Event_j + \sum \eta_k \beta_{k,i,t}/\sigma_{k,i,t} + \kappa Control_{i,t-1} + \varepsilon_{i,t}$$

where $\beta_{k,i,t}$, k=1, 2, 3, and 4 are the estimated sensitivity of log 2-day changes in CDS spreads to log 2-day changes in Baa-AAA spreads, on-off run 10-year Treasury spreads, 10-year Treasury rates, and VIX in the window [t-180,t-1]; $\sigma_{k,i,t}$ are standard errors of the β estimations; $Event_j$, j=1 to 16, are the QE, FG, and OT announcement dates; $Control_{i,t-1}$ are firms characteristics including maturing long-term debt, firm size, market to book ratio, market leverage ratio, tangibility, and profitability with no forward looking information. **To save space, this table only reports the estimations of $\Delta\gamma_{k,j}$.** The equations are estimated using the whole sample and IG and HY subsamples. Columns 1-3 report the estimations of $\Delta\gamma_{Baa_A AA,j}$; columns 4-6 report the estimations of $\Delta\gamma_{on\_off,j}$, columns 7-9 report the estimations of $\Delta\gamma_{T\ 10,j}$, and columns 10-12 report the estimations of $\Delta\gamma_{VIX,j}$. Firm-fixed effects are controlled. $***p < 0.01, **p < 0.05, *p < 0.1$

		$\Delta\gamma_{Baa\_AAA,j}$ (Expected sign if easing: -)			$\Delta\gamma_{on\_off,j}$ (Expected sign if easing: -)			$\Delta\gamma_{T10,j}$ (Expected sign if easing: +)			$\Delta\gamma_{VIX,j}$ (Expected sign if easing: -)		
		All	IG	HY	All	IG	HY	All	IG	HY	All	IG	HY
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
QE 1	QE 1_1	-0.004	-0.005*	-0.001	-0.012***	-0.013***	-0.010**	0.013***	0.013***	0.013***	-0.006**	-0.005*	-0.009**
	QE 1_2	0.008***	0.008***	0.010**	-0.006*	-0.007*	-0.005	0.000	0.001	-0.001	0.003	0.003	0.002
	QE 1_3	-0.011***	-0.011***	-0.013***	0.002	0.006	-0.002	0.007***	0.006**	0.010*	-0.011***	-0.005*	-0.021***
	QE 1_4	-0.009***	-0.007**	-0.011***	-0.004	-0.003	-0.005	0.004	0.004	0.002	-0.004	-0.001	-0.009**
	QE 1_5	-0.007***	-0.007**	-0.008*	0.006*	0.004	0.011*	-0.004	-0.002	-0.011*	-0.008***	-0.007**	-0.010**
QE 2	QE 2_1	0.001	0.002	0.001	0.001	0.003	-0.000	-0.003	-0.002	-0.004	0.009***	0.010***	0.008**
	QE 2_2	-0.003	-0.003	-0.005	0.000	0.005	-0.010*	-0.002	-0.001	-0.002	0.006***	0.008***	0.003
	QE 2_3	-0.004	-0.006*	0.002	0.002	0.001	0.003	0.003	0.005*	-0.001	-0.007***	-0.006***	-0.009***
OT	OT 2011	0.006**	0.007**	0.004	0.008***	0.007**	0.011**	-0.006**	-0.004	-0.009*	0.005**	0.006**	0.005
	OT 2012	-0.004	-0.005*	-0.002	-0.007**	-0.008**	-0.005	-0.003	-0.005	-0.000	0.003	0.001	0.005
FG	FG 2011	-0.008***	-0.008**	-0.006	-0.006*	-0.007*	-0.001	0.010***	0.005	0.017***	-0.004	-0.005	-0.004
	FG 2012	-0.004*	-0.003	-0.008**	-0.002	-0.001	-0.002	0.008***	0.007***	0.011***	-0.006***	-0.006*	-0.006*
Taper	QE 1 T_1	0.006**	0.008**	0.003	0.000	-0.003	0.007	0.002	-0.001	0.007	0.006**	0.009**	0.002
	QE 1 T_2	0.001	-0.001	0.004	-0.003	-0.004	-0.000	-0.001	-0.003	0.003	-0.005	-0.002	-0.008
	QE 1 T_3	-0.001	-0.002	0.000	0.006*	0.004	0.012*	-0.000	-0.002	0.004	0.003	0.003	0.002
	QE 2 T	-0.002	0.001	-0.005	-0.002	-0.004	0.001	0.000	0.001	-0.002	-0.000	-0.000	0.001