Corporate bond spreads and understated pension liabilities

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Abstract

Purpose – The question is whether debt market investors see through managers' attempts to hide their pension obligations. The authors establish a robust relation between understated pension liabilities and corporate bond yield spreads after controlling for factors that have been previously identified as having a significant impact on firms' cost of borrowing. The results support the idea that bond market investors are not being misled by the use of high pension liability discount rates by some companies to lower their reported pension obligations. For a small fraction of debt issuers, the reported pension liabilities are larger than the pension liabilities valued at the stipulated interest rate benchmarks. For these issuers with overstated pension liabilities, bond investors adjust their borrowing costs downward.

Design/methodology/approach – The authors investigate the relation between corporate bond yield spreads and understated pension liabilities relative to long-term Treasury and high-grade corporate bond yields. They aim to answer two questions. First, what are the sizes of over or understated pension liabilities relative to guideline benchmarks? Second, do debt market investors see through the potential management manipulation of pension discount rates? The authors find that firms with large understated pension liabilities face higher marginal borrowing costs after taking into account issue-specific features, firm characteristics, macroeconomic conditions and other pension information such as funded status and mandatory contributions.

Findings – The average understated projected benefit obligations (PBOs) are understated by \$394.3 and \$335.6, equivalent to 3.5 and 3.0% of the beginning of the fiscal year market value, respectively. The average understated accumulated benefit obligations (ABOs) are understated by \$359.3 and \$305.3 million, equivalent to 3.1 and 2.6%, of the beginning of the fiscal year market value, respectively. Relative to AA-grade corporate bond yields, the average difference between firm pension discount rates and benchmark yields becomes much smaller; the percentage of firm pension discount rates higher than benchmark yields is also much smaller. As a result, understated pension liabilities become negligible. The authors establish a robust relation between corporate bond yield spreads and measures of understated pension liabilities after controlling for issue-specific features, firm characteristics, other pension information (funded status and mandatory contributions), macroeconomic conditions, calendar effects and industry effects.

Originality/value – S&P Rating Services recognizes the issue that there is considerably more variability in discount rate assumptions among companies than in workforce demographics or the interest rate environment in which firms operate (Standard and Poor's, 2006). S&P also indicates that it would be desirable to normalize different discount rate assumptions but acknowledges that it is difficult to do so. In practice, S&P Rating Services conducts periodic surveys to see whether firms' assumed discount rates conform to the normal standard. The paper makes an initial attempt to quantify the size of understated pension liabilities and their impact on corporate bond yield spreads. This approach can be extended to study firms' costs of equity capital, the pricing of seasoned equity offerings and the pricing of merger and acquisition transaction deals, among other questions.

Keywords Corporate bond yield spread, Credit rating, Pension discount rates, Understated pension liabilities

Paper type Research paper

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1. Introduction

US corporate defined benefit pension plans offer employees a fixed payment upon retirement based on certain benefit formulas. These retirement benefits are considered off-balance sheet liabilities of the firms. Firms need to make some assumptions when calculating the present value of these obligations. The most important assumption is the pension discount rate. Choosing a high discount rate will lower the value of firms' pension liabilities. A small pension liability implies potentially less contributions immediately or in the near future. This is important for a firm that has limited access to credit or faces a rising marginal cost of funds. Otherwise, if the firm needs to issue debt to finance their investments or make contributions to pension assets, their cost of debt will increase.

Two guidelines exist for choosing pension discount rates. The first is instituted by the Employee Retirement Income Security Act (ERISA). Under ERISA, the interest rates used to calculate the present value of a plan's liabilities must be "within a specified range above or below the weighted average of the interest rates on 30-year Treasury bonds for the previous four-year period" [1], [2]. The ERISA guideline serves to determine the funding requirements for corporate pension plans. The second guideline is instituted by the Financial Accounting Standard Board (FASB). FASB statement SFAS 87 suggests "employers may also look to rates of return on high-quality fixed-income investments" for financial reporting purposes.

In reality, firms do not strictly follow these guidelines. Firms can choose their own pension discount rates, and they are often higher than the benchmark interest rates. This lowers the value of the pension liabilities disclosed in their 10-K reports. A rule of thumb is that a 1% change in the discount rate will lead to a 10%–15% change in the present value of future pension cash flow payments (Feldstein and Morck, 1983). This happens because pension liabilities are essentially long-term fixed-income instruments. They are very sensitive to small changes in pension discount rates. If managers exercise their discretion in choosing pension discount rates lower than their pension liabilities, it becomes an interesting question whether investors in the stock and bond markets can see through managers' discretional behavior and "pierce the veil" (Coronado and Sharpe, 2003).

The purpose of this paper is to investigate the relation between corporate bond yield spreads and understated pension liabilities relative to long-term Treasury and high-grade corporate bond yields. Specifically, we aim to answer two questions. First, what are the sizes of the over- or understated pension liabilities? Second, do capital market, in particular debt market, investors see through the potential management manipulation of pension discount rates and adjust firms' borrowing costs or corporate bond yields accordingly?

Our work is closely related to early work on pension information, capital market efficiency and financing friction and investment decisions (Picconi, 2006; Rauh, 2006; Franzoni, 2009; Campbell *et al.*, 2013). But our work differs from early studies in an important aspect. Picconi (2006) examines whether pension assets, pension liabilities and pension discount rates, among other pension parameters, can predict future returns. Rauh (2006) documents a negative relation between mandatory contributions and capital expenditures. Franzoni (2009) finds that stock market reaction to mandatory contributions is negative. Campbell *et al.* (2001) investigate the relation between mandatory contributions and firms' costs of capital. We, on the other hand, explore the issue of hidden pension liabilities that has not been studied in earlier literature.

The interest rate benchmarks we employ include 30-year Treasury bonds and 20- and 25-year AAA-grade corporate bonds. In addition, we construct term-structure AAA-grade corporate bond yields to take into account the difference in duration of pension liabilities. Likewise, we also employ 20- and 25-year AA-grade corporate bonds and term-structure AA-grade corporate bond yields. The empirical results within each corporate bond rating category but with different maturities, that is, 20 or 25 years maturities, are similar. We focus on the results from the 30-year Treasury bond yields and 20-year AAA and AA corporate bond yields.

Our major findings can be summarized as follows. First, our sample covers 2,213 debt issues by 593 firms from January 1989 to December 2013. For each of the 2,213 firm-year observations, we find the corresponding yields on 30-year Treasury bonds and 20-year AAA-grade corporate bonds. For the entire sample, the average pension discount rate is 6.11%, or 1.22 and 1.04% higher than the two benchmark yields, respectively. The majority, or 93.7 and 92.7%, of the 2,213 firm-year observations are associated with higher pension discount rates than these two benchmark yields, respectively. The average understated projected benefit obligations (PBOs) are understated by $394.3 and $335.6, equivalent to 3.5 and 3.0% of the beginning of the fiscal year market value, respectively. The average understated accumulated benefit obligations (ABOs) are understated by $359.3 and $305.3 million, equivalent to 3.1 and 2.6%, of the beginning of the fiscal year market value, respectively. Relative to AA-grade corporate bond yields, the average difference between firm pension discount rates and benchmark yields becomes much smaller; the percentage of firm pension discount rates higher than benchmark yields is also much smaller. As a result, understated pension liabilities become negligible.

Second, we measure marginal cost of debt using yield spreads on the first corporate debt issued during the fiscal year. Our yield spread is relative to AAA-grade corporate bond yields of the closest maturity rather than Treasury bond yields of the closest maturity. This allows us to cleanse some tax premium, bond market risk factor premium and liquidity premium that remain in corporate yield spread measured over Treasury bonds (Cooper and Davydenko, 2004; Chen *et al.*, 2007; Campello *et al.*, 2008).

In our empirical work, a large and negative value for mandatory contributions indicates firms are facing imminent cash outflows to meet the funding requirement of their pension plans. A large and negative value for understated pension liabilities indicates that firms are trying to hide more of their pension obligations. Using simple ordinary least squares (OLS) regressions, we establish a robust relation between corporate bond yield spreads and measures of understated pension liabilities after controlling for issue-specific features, firm characteristics, other pension information (funded status and mandatory contributions), macroeconomic conditions, calendar effects and industry effects. The highly significant estimates imply that debt market investors see through managers' attempts to manipulate pension discount rates and demand higher returns (yields) from bonds issued by those firms that try to hide more of their pension obligations. In comparison, mandatory contributions remain significant, but the explanatory power of funded status has essentially disappeared.

Third, the earlier literature generally agrees that corporate bond yield spreads and issue-specific credit ratings are jointly determined. Pension discount rates are decision variables. Our empirical evidence suggests that, in fact, the majority of firms exercise significant discretion when considering the appropriate discount rate for their pension annuities. Therefore, there is an endogeneity issue with respect to the positive relation between corporate bond yield spreads and various measures of understated pension liabilities. We consider a three-equation system in which corporate bond yield spread, issue-specific credit rating and understated pension liabilities are jointly determined. We use instrumental variable estimators, two-stage least square estimators, to estimate the relation. All model specifications pass the over-identifying restriction tests.

We find that in the equation determining corporate bond yield spreads, the instrumented (predicted) credit ratings and instrumented (predicted) understated pension liabilities have significant explanatory power. In the equation determining understated pension liabilities, instrumented issue-specific credit ratings are highly significant. This clearly indicates that firms with lower issue-specific credit ratings tend to hide more of their pension liabilities, and these understated pension liabilities cause firms to face higher marginal borrowing costs in debt markets.

Although we focus on corporate bond yields and pension information in the US, our empirical results have broad implications for empirical studies on corporate bond ratings and corporate bond yields in other markets as well. In particular, the corporate bond markets in China has developed rapidly in recent years. There is also a growing literature on issues related to corporate bond ratings and corporate bond yields in China (Amstad and He, 2020; Liu and Wang, 2020). Our results indicate that in addition to standard accounting ratios that appear in on-the-balance-sheet financial statements, off-the-balance-sheet accounting information such as pension information should also be taken into account.

The rest of the paper proceeds in the following way. Section 2 reviews the literature and develops five hypotheses. Section 3 describes the data sources, summarizes the relevant FASB statements, screens the debt issue sample and defines variables used in the study. Section 4 provides empirical results, including summary statistics, a comparison of pension discount rates and benchmark interest rates, the size of understated pension liabilities, the determinants of corporate bond yield spreads and two-stage least square (2SLS) regressions. Finally, Section 5 concludes the paper.

2. Literature review and hypothesis development

2.1 Literature review

2.1.1 Understated pension liabilities. Questions of liability discounting, similar to those we address, arise in the measuring of public pension liabilities (Brown and Wilcox, 2009; Novy-Marx and Rauh, 2009, 2011). Novy-Marx and Rauh (2011) report much larger state public pension liabilities after applying financial valuation to the pension liabilities of the US states using appropriate discount rates rather than the expected rate of return on pension assets stipulated under the Government Accounting Standards Board. Lucas and Zeldes (2009) develop a theoretical model to link public pension asset allocation to public pension liability risk. Andonov *et al.* (2013) report that while private pension funds generally lower liability discount rates as interest rates decline, this is not the case for public pension funds. Hann *et al.* (2007) develop methods for obtaining estimates on corporate pension benefit formula parameters. They replace the assumed discount rate with the corresponding industry median discount rate and examine the value relevancy of discretionary versus nondiscretionary components of PBOs.

Our implicit assumption in measuring over- or understated pension liabilities is that the discount rate for pension annuities is constant. This follows the approach of Brown and Wilcox (2009) and Novy-Marx and Rauh (2009, 2011). An alternative approach recognizes the fact that for PBOs, the discount rate for pension annuities is time-varying, because PBOs depend on expected future wages and aggregate wage growth rates are correlated with stock market returns (Black, 1989; Lucas and Zeldes, 2006). This risk should be reflected in the discount rate for PBOs. For ABOs, the problem does not exist because ABOs depend on the current wage rather than on the expected future wage. This alternative approach has the problem of requiring additional labor income data and empirical tractability for a large cross-section of firms. For this reason, we adopt the simple approach of discount pension annuities at constant stipulated benchmark interest rates [3].

2.1.2 Pension information and capital market efficiency. A few earlier studies consider the impact of pension information on credit rating (Martin and Henderson, 1983; Maher, 1987; Carroll and Niehaus, 1998). Campbell *et al.* (2012) examine the effect of pension information on corporate bond yield spreads. They consider the role of funded status and mandatory contributions in both credit rating and cost of capital including cost of debt. Picconi (2006) investigates whether pension assets, pension liabilities and pension discount rates, among other pension parameters, can predict future returns. He concludes that investors only gradually incorporate pension information into future stock prices. Rauh (2006) documents a negative relation between mandatory contributions and capital expenditures. Franzoni (2009) reports a negative association between mandatory contributions and stock returns over the subsequent twelve months.

2.1.3 The determinants of corporate bond yield spreads. There is a large body of research on the pricing of corporate bonds and time-series and cross-sectional determinants of corporate bond yield spreads. The literature begins with structural models developed in Black and Scholes (1973), Merton (1974), Ingersoll (1977), Longstaff and Schwartz (1995), Leland and Toft (1996) and Collin-Dufresne *et al.* (2001). Others have employed reduced form models and identify a number of important factors that help explain corporate bond yield spreads. These include Jarrow and Turnbull (1995), Duffie and Singleton (1997, 1999), Duffee (1998, 1999), Elton *et al.* (2001) and Campbell and Taksler (2003).

More recently, the focus of the corporate bond literature falls into the following categories. The first explores the relation between yield spread and corporate debt liquidity or bond returns and liquidity (Ericsson and Renault, 2002; Downing et al., 2005; Chen *et al.*, 2007; Mahanti *et al.*, 2008; Bao *et al.*, 2011; Lin *et al.*, 2011; Nashikkar *et al.*, 2011; Huang and Huang, 2012).

The second category investigates the economic and information role of rating changes issued by multiple rating agencies (Bongaerts *et al.*, 2012) and the impact of credit rating–related regulatory changes on cost of debt capital (Kliger and Sarig, 2000; Tang, 2009; Kisgen and Strahan, 2010).

The third category examines family ownership and agency cost of debt (Anderson *et al.*, 2003) and the effect of disclosure quality, financial statement transparency, ownership structure and corporate governance on yield spreads and bond ratings (Sengupta, 1998; Bhojraj and Sengupta, 2003; Klock *et al.*, 2005; Ashbaugh-Skaife *et al.*, 2006) [4], [5].

The fourth category explores the role of market transparency on corporate bond trading costs and liquidity (Bessembinder *et al.*, 2006; Goldstein *et al.*, 2007; Edwards *et al.*, 2007). These studies examine the impact on corporate bond trading following NASDAQ's initiative to report over-the-counter bond transactions through its TRACE system after July 1, 2002 [6]

2.2 Hypothesis development

Our study adds to the literature by first comparing the level of pension discount rates with alternative interest rate benchmarks and then examining how pension discount rates respond to changes in benchmark interest rates. Then our study documents the size of understated pension liabilities and relates understated pension liabilities to corporate bond yield spread, after controlling for other factors that explain the time-series and cross-section variation of corporate bond yield spreads. Specifically, we intend to examine the following five hypotheses:

- *H1.* The gap between pension discount rates and 30-year Treasury bond yields is the largest, followed by the gap between pension discount rates and AAA-grade corporate bond yields, and the gap between pension discount rates and AA-grade corporate bond yields.
- *H2.* Pension discount rates respond to changes in benchmark interest rates by less than one for one.
- *H3.* Funded status are positively associated with corporate bond yield spreads.
- *H4.* Mandatory contributions are positively associated with corporate bond yield spreads.

H5. Understated pension liabilities are positively associated with corporate bond yield spreads.

3. Data sources, sample screening and variable definitions

3.1 Data sources

The data for US equity markets are from WRDS's CRSP and COMPUSTAT merge files. We obtain market capitalization, daily individual stock returns and value-weighted market portfolio returns from CRSP. The annual accounting items and pension variables are from COMPUSTAT. Corporate debt issue samples and debt issue characteristics are from Mergent Corporate Bond Securities Database (FISD). S&P individual debt ratings are also from FISD. The data for 1-, 2-, 3-, 5-, 7-, 10-, 20- and 30-year Treasury bond yields are from WRDS. One-month Eurodollar rates are from WRDS. The yields on AAA-grade and AA-grade corporate bond yields are from Barclays Bank PLC. We obtain 1-, 3-, 5-, 7-, 10-, 15-, 20-, 25- and 30-year yields and number of bonds used to calculate the yields for AAA-grade and AA-grade corporate bonds [7]. Barclays' 15-year maturity bonds include bonds with maturity between 15 and 19 years. Similarly, Barclays' 20-, 25- and 30-year maturity bonds cover bonds with maturities between 20–24, 25–29 and 30 and above years, respectively. For a subset of bonds issued after July 2002, the transaction-by-transaction data are from TRACE. We exclude financial firms with 4-digit SIC codes between 6000 and 6999.

3.2 FASB statements

We start sample screening for the January 1988 to December 2013 period. The year 1988 is chosen as the beginning fiscal year because SFAS 87 imposes new standards on pension reporting, effective after December 1986. Under SFAS 87, ABOs determine recognition of minimum liability and PBOs are used in determining net periodic cost. SFAS 87 basically requires a smoothed model for pension accounting that gradually incorporates fair value funded status, or the difference between plan assets and PBOs. Under SFAS 132, effective in 1998, FASB eliminates the disclosure requirement for ABOs when plan assets are in excess of ABOs. But the disclosure of ABOs is still necessary when ABOs exceed plan assets. Under SFAS 132(R), effective in 2003, FASB again requires the disclosure of the ABO. Under SFAS 158, effective after December 2006, firms are required to immediately incorporate fair value funded status in their consolidated statements.

3.3 FISD debt issue sample

FISD contains 106,309 corporate debts issued by 7,411 issuers during the January 1988 to December 2013 period. These debts carry a total of 322,106 monthly ratings assigned by S&P during the same period. The sample of FISD debts includes redeemable, puttable and convertible bonds, and bonds with various covenants or other features. We impose only two requirements: first, that debt issues have bond-type codes of CDEB, CMTN, CMTZ, CPAS, CPIK, CS, CZ, RNT or USBN [8]; second, that coupon payments are fixed and payment frequency is twice a year. The pension data set from COMPUSTAT contains 29,039 firm-year observations with non-missing plan assets (PAs) and PBOs on 2,338 firms over the same period [9]. Following earlier literature, we consider the first corporate debt issue after the fiscal year. The spread on the first debt issue measures the marginal cost of debt capital (MacKie-Mason, 1990; Sengupta, 1998; Datta *et al.*, 1999; Denis and Mihov, 2003; Shi, 2003; Mansi *et al.*, 2004; Jiang, 2008). We hope to retain firm-year observations with both (1) pension information for the fiscal year and (2) a FISD corporate debt issue with a corresponding S&P debt rating. In merging these two data sets, we require that pension data be available for the fiscal year. The debt's offering month must be within the same fiscal year. S&P individual debt's rating month is after the offering month but within one year of the offering month. Our final sample consists of 2,213 firm-year observations from 593 firms during the January 1989–December 2013 period [10–12].

3.4 Variable definitions

The dependent variable in this study is the offering yield at the time of issue in excess of the yield on AAA-grade corporate bonds with the closest maturity. The majority of earlier studies on corporate bond yield spreads measure the spread relative to Treasury bonds of the closest maturity. Empirical evidence suggests that the expected default component of AAA bond spreads is very low (Elton *et al.*, 2001); thus, spreads on AAA bonds reflect almost entirely non-default factors such as tax, bond market risk and liquidity. We use the AAA yield instead of the Treasury yield to calculate the spreads. This allows us to cleanse some tax, bond market risk and liquidity components in the corporate bond yields. Notice that corporate bonds are subject to state and local taxes, while Treasury bonds are not. The independent variables can be categorized into four groups: (1) debt issue characteristics, (2) firm characteristics, (3) macroeconomic variables and (4) pension variables. We discuss each in separate sections.

3.4.1 Debt issue characteristics. We include the following debt issue characteristics: S&P debt rating, maturity, amount offered and coupon rate, as well as dummies for corporate debts' seniority status, debt issues that are fungible, debt issues under tender or exchange offer method and investment grade bonds.

S&P assigns credit ratings to both the issuing company and specific debt issues. S&P often differentiates issues in relation to the issuer's credit worthiness, a practice known as "notching." Specific debt issues are notched up or down from the corporate credit rating level. For our purpose, we assign ordinal numbers from 22 to 1 for AAA, AA+, AA, AA−, *A*+, A, A−, BBB+, BBB, BBB−, BB+, BB, BB−, B+, B, B−, CCC+, CCC, CCC−, CC, C and D. Both maturity and amount of debt offered serve as proxy for cross-sectional differences in corporate bond liquidity (Longstaff *et al.*, 2005).

3.4.2 Firm characteristics. We consider the following variables to capture firm characteristics that affect either yield spreads or S&P debt ratings: inflation adjusted market value in constant 2013 US billion $ (*ME_INF*), interest coverage (*COVERAGE*), operating margin (*MARGIN*), long-term debt leverage (*LLEV*), the ratio of fixed assets to total assets (*PPE*) and time-trend adjusted residual standard deviation (*ASTD*) [13]. The details of the construction of these variables using COMPUSTAT items are provided in Appendix 1. We essentially follow Blume *et al.* (1998) in both the selection and construction of these variables.

3.4.3 Macroeconomic variables. The macroeconomic environment, especially interest rate, has important implications for corporate bond spreads. The literature, in general, considers three measures. The first is the level of the short-term interest rate, such as one-year Treasury note yields (Longstaff and Schwartz, 1995; Leland and Toft, 1996). The second macroeconomic variable is the term premium, such as the difference between 10-year Treasury bond yields and two-year Treasury note yields (Collin-Dufresne *et al.*, 2001; Campbell and Taksler, 2003; Chen *et al.*, 2007). The third macroeconomic variable is the difference between one-month Eurodollar rates and three-month Treasury bill yields (Longstaff, 2004; Longstaff *et al.*, 2005).

3.4.4 Pension variables. Pension plan–related variables include plan assets (*PA*), projected benefit obligations (*PBO*), accumulated benefit obligations (*ABO*), funded status (*FS*) and Moody's measurement of mandatory contributions (*MC*). The details of the construction of these variables using COMPUSTAT items are provided in Appendix 1. The definitions of understated pension liabilities, understated PBOs (*PCT_TB30Y, PCT_AAA20Y, PCT_AAA25Y, PCT_AAATM, PCT_AA20Y, PCT_AA25Y, PCT_AATM)* and understated ABOs *(APCT_TB30Y, APCT_AAA20Y, APCT_AAA25Y, APCT_AAATM, APCT_AA20Y, APCT_AA25Y, APCT_AATM*) are provided in Appendix 2.

The two variables of interest in the earlier literature are funded status and mandatory contributions. Funded status (*FS*) is the difference between plan assets (*PA*) and projected benefit obligations (*PBO*). In general, firms need to make obligatory contributions to pension plans with dedicated assets. For overfunded plans in which *PA* exceeds *PBO*, firms do not have to make contributions. For underfunded plans in which *PBO* exceeds *PA*, firms are required by law to make contributions. The size of the contribution is a nonlinear function of funded status (*FS*) [14]. Rauh (2006) uses IRS 5500 filings to the US Labor Department to compute funding requirements for individual pension plans within each firm.

Moody uses an alternative measure for mandatory pension contributions (Mathur *et al.*, 2006). Moody's formula for determining mandatory pension contributions relies on publicly available accounting disclosures in the 10-K reports, while IRS 5500 forms generally release data with a significant lag. Moody's defines mandatory pension contributions (*MC*) as the sum of pension expenses earned by employees during the current fiscal period and the amortization of any funding shortfall. Specifically,

$$\begin{aligned} MC_{i,t} &= -(SC_{i,t} + (ABO_{i,t} - PA_{i,t})/30), \quad && if\ PBO_{i,t} \geq PA_{i,t}, \\ &= 0, && if\ PBO_{i,t} < PA_{i,t}, \end{aligned} \tag{1}$$

where the funding shortfall of *ABO–PA* under ERISA is supposed to be amortized over a 5–30-year period before 2006. Under the Pension Protection Act of 2006, firms are required to fully fund their pension plans within seven years [15]. The *MC* measure takes on non-positive values. A large negative *MC* value indicates that firms face imminent cash outflows to fulfill the funding requirements for their pension plans. For both *FS* and *MC*, we scale by beginning of the fiscal year market value.

4. Empirical results

4.1 Summary statistics

We begin the empirical analysis by providing summary statistics in Table 1. We winsorize firm characteristics and pension variables at 1 and 99% to mitigate the influence of outliers. Panel A shows that the mean corporate bond yield is 6.33% and the mean corporate bond yield spread is 2.60%. As expected, our yield spread of 2.60% relative to the AAA-grade corporate bond yield is smaller than the yield spread relative to the Treasury bond yield of 2.94% from our sample. Klock *et al.* (2005) and Campbell *et al.* (2012) report average yield spreads of 1.93 and 1.61%, respectively, relative to the Treasury bond yield for different sample periods. The average credit rating is 14.37, corresponding to a credit rating of BBB. The average maturity of the bonds is 11.28 years. The average amount offered is $412.6 million. The average coupon rate is 6.28%.

Panel A shows that the average funded status is −3.75% and the average mandatory contribution is −0.56% of the beginning of the fiscal year market value.

Panel B also reports the pairwise correlations within each of the four categories of variables. Yield spread has a significant negative correlation of −0.13 and −0.14, respectively, with funded status and mandatory contributions. Funded status and mandatory contributions have a significant positive correlation of 0.83, implying that a negative funded status is associated with higher mandatory contributions. Again, the mandatory contribution measure is non-positive, and a large negative value indicates large cash outflows in the near future.

4.2 Pension discount rates and interest rate benchmarks

In this section, we examine two issues. First, we compare the level of the pension discount rates with yields on the following interest rate benchmarks: 30-year Treasury bond,

Panel A: Summary statistics		25%	Mean	Median	75%	Std. Dev
Issue characteristics						
Corporate bond yield (%)	*YIELD*	4.987	6.330	6.500	7.730	2.194
Corporate bond yield spread (%)	*SPREAD*	0.660	2.603	1.855	4.177	2.589
S&P debt rating	*RATING*	13.000	14.369	15.000	17.000	3.321
Maturity	*MAT*	6.000	11.284	10.000	10.000	9.691
Offered amount ($1,000)	*OAMT*	200,000	412,630	300,000	500,000	367,031
Coupon (%)	*COUP*	4.950	6.275	6.500	7.625	2.170
Firm characteristics						
Market size (billion US$ in 2013)	*ME_INF*	2.700	20.498	7.440	21.449	35.218
Interest coverage	*COVERAGE*	2.394	7.409	4.546	8.765	9.397
Operating margin	*MARGIN*	0.116	0.195	0.174	0.252	0.112
Long term debt leverage	*LLEV*	0.198	0.296	0.281	0.370	0.133
Ratio of fixed assets to total assets	*PPE*	0.178	0.380	0.333	0.562	0.234
Adjusted residual standard deviation	*ASTD*	0.572	0.800	0.715	0.940	0.334
Pension variables						
Funded status (%)	*FS*	−5.078	−3.750	−1.397	−0.002	10.888
Mandatory contribution (%)	*MC*	−0.708	−0.560	−0.276	0.001	0.861
Macroeconomic variables						
One year T-note yield (%)	*TB1Y*	0.290	2.488	2.170	4.530	2.220
Term premium	*TERM*	0.420	1.464	1.580	2.330	0.966
Eurodollar premium	*ED1TB3*	0.130	0.315	0.220	0.340	0.414

Panel B: Pairwise correlations						
Issue characteristics						
	SPREAD	*RATING*	*MAT*	*OAMT*	*COUP*	
YIELD	0.55**	−0.39**	0.17**	−0.27**	0.99**	
SPREAD		−0.26**	0.58**	−0.07**	0.54**	
RATING			0.17**	0.11**	−0.40**	
MAT				−0.05**	0.17**	
OAMT					−0.27**	
Firm characteristics						
	ME_INF	*COVERAGE*	*MARGIN*	*LLEV*	*PPE*	*ASTD*
SPREAD	−0.18**	−0.23**	−0.08**	0.16**	0.10**	0.25**
ME_INF		0.34**	0.22**	−0.31**	−0.16**	−0.28**
COVERAGE			0.16**	−0.41**	−0.23**	−0.19**
MARGIN				0.09**	0.35**	−0.23**
LLEV					0.21**	0.29**
PPE						−0.02
Pension variables						
	FS	*MC*				
SPREAD	−0.13**	−0.14**				
FS		0.83**				

(*continued*)

Table 1.
Summary statistics

Table 1.

Panel B: Pairwise correlations			
Macroeconomic variables			
	TB1Y	*TERM*	*ED1TB3*
SPREAD	−0.01	0.04**	0.02
TB1Y		−0.82**	0.13**
TERM			−0.22**

Note(s): The sample covers 2,213 firm-year observations from January 1989 to December 2013. Panel A of the table provides summary statistics for variables that belong to the following categories: issue characteristics, firm characteristics, macroeconomic variables and pension variables. Issue characteristics include corporate debt yield at issue (*YIELD*), corporate debt spread (*SPREAD*), S&P debt rating (*RATING*), maturity (*MAT*), offered amount (*OAMT*) and coupon rate (*COUP*). Firm characteristics include inflation-adjusted market value in constant 2013 US billion dollar (*ME_INF*), interest coverage (*COVERAGE*), operating margin (*MARGIN*), long-term debt leverage (*LLEV*), ratio of fixed assets to total assets (*PPE*) and time-trend adjusted residual standard deviations (*ASTD*) within each fiscal year. Macroeconomic variables include one-year Treasury note yield (*TB1Y*), term premium or the difference between 10-year and one-year Treasury note yields (*TERM*) and Eurodollar premium or the difference between the one-month Eurodollar rate and three-month Treasury bill rate (*ED1TB3*). Pension variables include funded status (*FS*) and mandatory contributions (*MC*). Panel B reports pairwise correlations. The definitions of the variables are provided in Appendix 1. Corporate debt spreads are the difference between corporate debt yield at issue and the corresponding AAA-grade corporate debt yield of the closest maturity. S&P debt ratings are numbered from 22 for AAA to 1 for D. ** indicates significance at the 5% level; * indicates significance at the 10% level

AAA-grade corporate bond and AA-grade corporate bond. Second, we examine how much pension discount rates adjust following changes in interest rate benchmarks. Figure 1 plots the annual average of the monthly yields on alternative interest rate benchmarks. In general, Figure 1 shows that the interest rate drops unprecedentedly from 9% in 1989 to 3% in 2013. There is a similarly dramatic drop in the high-grade AAA and AA corporate bond yields.

4.2.1 A comparison of discount rate and interest rate benchmarks. Table 2 compares the pension discount rates with alternative interest rate benchmarks. For each of the 2,213 firm-year observations, we find the corresponding yields on the 30-year Treasury bond, 20-year and 30-year AAA-grade corporate bonds, and 20-year and 30-year AA-grade corporate bonds.

In addition, we also construct term structure benchmarks using AAA-grade and AA-grade corporate bonds with target maturities, respectively. This allows us to capture the demographic differences in the workforce. PBOs are long-term fixed liabilities for firms. PBOs should be discounted using interest rates with a matched duration. For firms with a relatively young workforce, the duration of PBOs will be high compared to firms with a relatively mature workforce. To capture the differences in PBO duration, we employ two proxies. The first is based on the ratio of service cost to interest cost. A higher ratio of service cost to interest cost indicates a relatively young workforce. This is because for firms with a young workforce, the level of PBOs will be low, and interest cost, which is based on the beginning of the period PBOs, will be low relative to current service cost. For firms with a mature workforce, the level of PBOs will be high, and interest cost will be high relative to current service cost. The second is based on our estimated values of number of years to retirement $\widehat{N}$. These two proxies have a significant positive correlation of 0.23 (p-value = 0.00). We construct term-structure AAA yields using the 15, 20, 25 and 30-year AAA yields based on the quartile group cutoff points. The quartile group with the lowest ratios of service to interest cost, and therefore a mature workforce, is assigned the 15-year AAA yields. The quartile group with the highest ratios of service to interest cost, implying a young workforce, is assigned the 30-year AAA yields. Similarly, we construct term-structure AA yields using the 15, 20, 25 and 30-year AA yields based on the quartile group

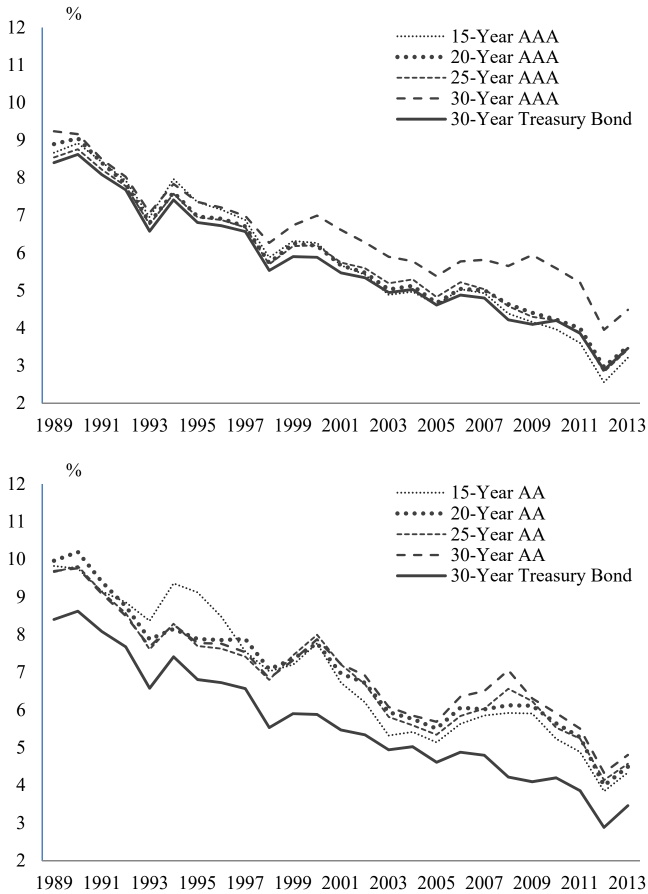

Figure 1. Long-term treasury bond and high-grade corporate bond yields

cutoff points. Since all of the empirical results from the ratio of service cost to interest cost and $\widehat{N}$ are essentially the same, we only report the results for the term structure yields based on the ratio of service cost to interest cost [16].

Panel A1 of Table 2 first presents the difference between pension discount rates and alternative interest rate benchmarks, $r^{DISCOUNT} - r^{Benchmark}$. For our sample of 2,213 firm-year observations, the average pension discount rate is 6.11%. The first column shows that the average differences between pension discount rate and benchmark interest rate are 1.22%, 1.04%, 1.07% and 0.97%, respectively, relative to the 30-year Treasury bond, 20-year, 25-year and term-structure AAA-grade corporate bond yields. The average differences become negative, or −0.10%, −0.04% and −0.04%, respectively, relative to the 20-year, 25-year and term-structure AA-grade corporate bond yields. Figure 2 plots the evolution of pension discount rates and corresponding interest rate benchmarks for each year from 1989 to 2013. The average is taken among all firm-year observations within each calendar year. Figure 2 clearly reveals three patterns: (1) the gap between pension discount rates and 30-year Treasury bond yields is the largest, followed by the gap between pension discount rates and AAA-grade corporate bond yields; (2) the gap between pension discount rates and AA-grade

Panel A1: Percentage Difference in $r^{DISCOUNT} - r^{Benchmark}$

	Sample 1		Sample 2	
	Mean	Median	Mean	Median
$r^{DISCOUNT} - r^{TB30Y}$	1.22	1.17	1.08	1.14
$r^{DISCOUNT} - r^{AAA20Y}$	1.04	1.05	0.88	0.99
$r^{DISCOUNT} - r^{AAA25Y}$	1.07	1.07	0.90	0.97
$r^{DISCOUNT} - r^{AAATM}$	0.97	1.04	0.80	0.94
$r^{DISCOUNT} - r^{AA20Y}$	−0.10	0.01	−0.25	−0.06
$r^{DISCOUNT} - r^{AA25Y}$	−0.04	0.06	−0.17	0.04
$r^{DISCOUNT} - r^{AATM}$	−0.04	0.07	−0.20	0.01
Observations	2,213	2,213	9,654	9,654

Panel A2: Percentage of firm-year observations with $r^{DISCOUNT} > r^{Benchmark}$

	Sample 1	Sample 2
$r^{DISCOUNT} > r^{TB30Y}$	93.7	89.5
$r^{DISCOUNT} > r^{AAA20Y}$	92.7	87.2
$r^{DISCOUNT} > r^{AAA25Y}$	92.8	87.2
$r^{DISCOUNT} > r^{AAATM}$	89.3	84.3
$r^{DISCOUNT} > r^{AA20Y}$	50.0	45.3
$r^{DISCOUNT} > r^{AA25Y}$	56.4	54.1
$r^{DISCOUNT} > r^{AATM}$	56.7	50.8
Observations	2,213	9,654

Panel B: OLS regressions of changes in pension discount rates on changes in interest rates

	Model				
	1	2	3	4	5
Constant	−0.002 (−3.86)**	−0.002 (−3.43)**	−0.002 (−3.73)**	−0.001 (−1.27)	−0.001 (−1.04)
Δr^{TB30Y}	0.167 (19.96)**				
Δr^{AAA20Y}		0.215 (23.90)**			
Δr^{AAA25Y}			0.195 (22.19)**		
Δr^{AA20Y}				0.382 (31.60)**	
Δr^{AA25Y}					0.407 (36.41)**
Year dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.220	0.236	0.229	0.282	0.318
Observations	9,654	9,654	9,654	9,654	9,654

Note(s): The primary sample (Sample 1) covers 2,213 firm-year observations from January 1989 to December 2013. The secondary sample (Sample 2) covers 9,654 firm-year observations for the same period. The primary sample requires availability of the pension discount rate and that firms issue debts during the fiscal year. The secondary sample requires availability of the pension discount rate but does not require that firms issue debts during the fiscal year. Both samples cover the same set of firms. Panel A1 of the table provides the difference between the pension discount rate ($r^{DISCOUNT}$) and the alternative interest rate benchmarks such as 30-year Treasury bond yields (r^{TB30Y}), 20-year and 25-year AAA-grade corporate bond yields (r^{AAA20Y} and r^{AAA25Y}), 20-year and 25-year AA-grade corporate bond yields (r^{AA20Y} and r^{AA25Y}) and term-structure AAA-grade and AA-grade corporate bond yields (r^{AAATM} and r^{AATM}). For each firm-year observation with a pension discount rate, a corresponding yield r^{TB30Y}, r^{AAA20Y}, r^{AAA25Y}, r^{AA20Y}, r^{AA25Y}, r^{AAATM}, and r^{AATM} is first matched. Then, the mean and median statistics are calculated. Panel A2 reports the percentage of firm-year observations for which the pension discount rate is higher than the corresponding interest rate benchmarks. Panel B regresses changes in discount rates $\Delta r^{DISCOUNT}$ on changes in benchmark interest rates Δr^{TB30Y}, Δr^{AAA20Y}, Δr^{AAA25Y}, Δr^{AA20Y}, and Δr^{AA25Y}, respectively. ** indicates significance at the 5% level; * indicates significance at the 10% level

Table 2.
Pension discount rate, treasury bond yield and high grade corporate bond yield

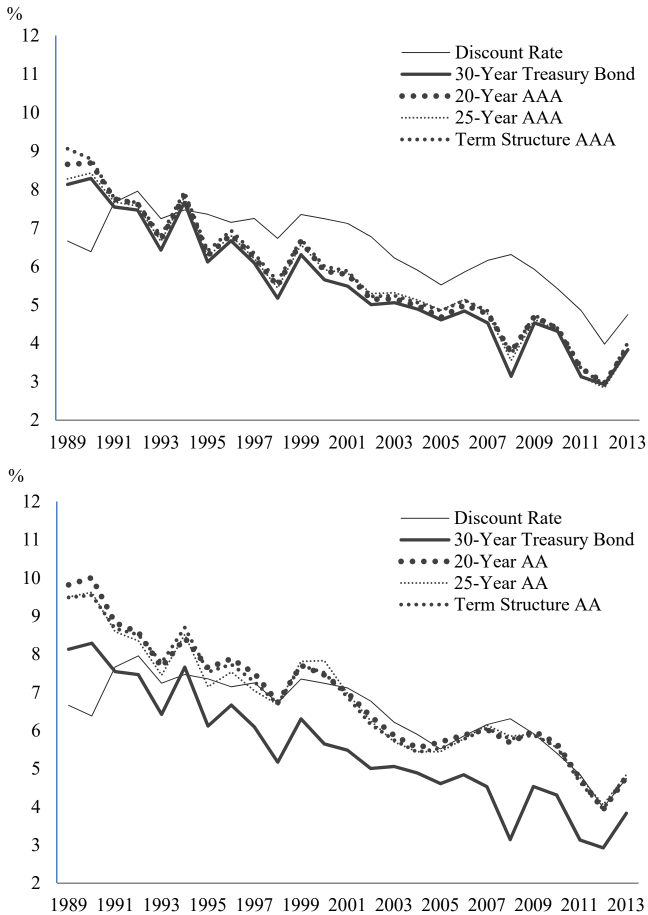

Figure 2.
Pension discount rates and interest rate benchmarks

corporate bond yields is the smallest; and (3) the gap seems to be persistent over time and seems to become wider in later years of the sample period.

Panel A2 also summarizes the percentage of firm-year observations with pension discount rates larger than the corresponding interest rate benchmark. For example, the first column shows that 93.7% of the 2,213 pension discount rates are larger than the corresponding 30-year Treasury bond yields, while 92.7%, 92.8% and 89.3% are larger than the 20-year, 25-year and term-structure AAA-grade corporate bond yields, respectively. The percentages drop precipitously to 50.0%, 56.4% and 56.7% relative to the three AA-grade benchmark yields [17], [18].

4.2.2 Pension discount rate adjustments. Now we are ready to examine the issue related to pension discount rate adjustments. Specifically, which interest rate benchmarks are firms' pension discount rates most responsive to? We implement the analysis by running the following regression:

$$\Delta r_{i,t}^{\mathrm{DISCOUNT}} = \lambda_0 + \lambda_1 \Delta r_{i,t}^{\mathrm{Benchmark}} + \sum_{j=1}^{12} YD_j + \sum_{k=1}^{28} ID_k + \varepsilon_{i,t}, \tag{2}$$

where $r^{\text{Benchmark}}$ stands for the benchmark interest rate. We also include 12 calendar year dummies YD_j, $j = 1, \ldots, 12$, and 28 industry dummies, ID_k, $k = 1, \ldots, 28$ [19]. The coefficients on the dummy variables are omitted. The regression employs pension discount rate observations between consecutive fiscal years from the second sample with 9,654 firm-year observations. In this way, changes in pension discount rates can be measured. We consider the following list of benchmarks: 30-year Treasury bond yields, AAA yields with 20-year and 25-year maturities, and AA yields with 20-year and 25-year maturities. From Panel B of Table 2, the estimate for the slope coefficient (t-stat.) is 0.167 (19.96) when the benchmark is the 30-year Treasury bond. This implies that a 100 basis point drop in long-term Treasury bond yields will result in a 16.7 basis point drop in pension discount rates. The estimates (t-stat.) are 0.215 (23.90) and 0.195 (22.19) when the benchmarks are 20-year and 25-year AAA-grade corporate bond yields. The estimates (t-stat.) are 0.382 (31.60) and 0.407 (36.41) when the benchmarks are 20-year and 25-year AA-grade corporate bond yields. Overall, pension discount rates respond to changes in benchmark interest rates by less than one for one. They are more sensitive to changes in AA-grade corporate bond yields with larger slope coefficients. The evidence is consistent with that of Andonov *et al.* (2013).

4.3 How much do firms understate their pension liabilities?

In order to estimate the value of PBOs and ABOs relative to alternative interest rate benchmarks, we need to find the estimates for pension benefit formula parameters such as number of years to retirement, percentage of current salary to be received after retirement and current wages. These items are not available from COMPUSTAT. We follow Hann *et al.* (2007) to obtain these parameters at the aggregate firm level. Then, we replace the assumed pension discount rate by alternative interest rate benchmarks to obtain the new PBO or ABO values. The details for calculating understated pension liabilities are provided in Appendix 2. The understated PBO is the difference between the reported PBO and PBO^{TB30Y} (PBO discounted at 30-year Treasury bond yields) divided by the beginning of the fiscal year market value $ME(-1)$:

$$PCT\_TB30Y = \frac{PBO - PBO^{TB30Y}}{ME(-1)}. \tag{3}$$

The understated ABO is the difference between the reported ABO and ABO^{TB30Y} divided by the fiscal year end market value $ME(-1)$:

$$APCT\_TB30Y = \frac{ABO - ABO^{TB30Y}}{ME(-1)}. \tag{4}$$

We scale the understated pension liabilities by market capitalization. This follows Franzoni and Marin (2006) who scale funded status (FS) by market capitalization and argue that using market capitalization is better than using total assets to scale. From Table 2, since the average pension discount rate is 1.22 percentage points higher than the average yield from the 30-year Treasury bond, we expect the average value for PCT_TB30Y and $APCT\_TB30Y$ to be negative, indicating understated PBOs and ABOs relative to the long-term Treasury bond benchmark. Understated PBOs and ABOs relative to AAA-grade and AA-grade corporate bond yields are calculated in an analogous way.

Now we can proceed to examine understated pension liabilities in dollar amount and in percentage. For our sample of 2,213 firm-year observations, Panel A of Table 3 summarizes the 5%, 25%, mean, median, 75% and 95% values of understated pension liabilities relative to alternative interest rate benchmarks. We focus on the mean figures. Panel A shows that the average of the understated PBOs is \$394.3 million using r^{TB30Y} as the benchmark. The numbers

Table 3. Understated pension liabilities

Panel A: Understated PBOs and ABOs

	5%	25%	Mean	Median	75%	95%
Benchmark			Understated PBOs (million $)			
r^{TB30Y}	−2042.9	−325.1	−394.3	−87.1	−19.9	9.8
r^{AAA20Y}	−1689.5	−285.1	−335.6	−75.1	−16.3	16.1
r^{AAA25Y}	−1802.3	−276.5	−352.1	−76.2	−16.5	16.1
r^{AAATM}	−1718.5	−263.0	−343.6	−68.8	−11.2	30.4
r^{AA20Y}	−280.1	−24.4	2.2	−0.1	17.8	281.3
r^{AA25Y}	−279.2	−29.8	−5.7	−1.6	12.7	283.5
r^{AATM}	−372.5	−32.0	−14.2	−1.8	13.3	270.3
			Understated PBOs (%)			
r^{TB30Y}	−13.0	−4.3	−3.5	−1.8	−0.6	0.2
r^{AAA20Y}	−11.3	−3.7	−3.0	−1.5	−0.5	0.3
r^{AAA25Y}	−11.8	−3.8	−3.0	−1.5	−0.5	0.3
r^{AAATM}	−12.4	−3.8	−3.0	−1.4	−0.4	0.5
r^{AA20Y}	−2.3	−0.4	0.1	−0.1	0.4	3.1
r^{AA25Y}	−2.6	−0.6	−0.1	−0.1	0.2	2.8
r^{AATM}	−3.3	−0.6	−0.2	−0.1	0.3	3.0
			Understated ABOs (million $)			
r^{TB30Y}	−1825.0	−289.5	−359.3	−77.7	−17.7	8.5
r^{AAA20Y}	−1526.6	−255.4	−305.3	−66.7	−14.6	13.9
r^{AAA25Y}	−1612.3	−251.9	−321.1	−68.0	−14.4	14.2
r^{AAATM}	−1609.0	−238.7	−315.1	−60.6	−9.9	27.0
r^{AA20Y}	−249.8	−21.1	3.1	−0.1	15.5	251.0
r^{AA25Y}	−249.6	−26.8	−3.4	−1.3	11.5	262.6
r^{AATM}	−333.7	−29.3	−13.3	−1.6	11.7	243.3
			Understated ABOs (%)			
r^{TB30Y}	−11.4	−3.8	−3.1	−1.6	−0.5	0.2
r^{AAA20Y}	−10.0	−3.3	−2.6	−1.3	−0.4	0.3
r^{AAA25Y}	−10.5	−3.4	−2.7	−1.4	−0.4	0.3
r^{AAATM}	−11.2	−3.5	−2.7	−1.3	−0.3	0.5
r^{AA20Y}	−2.1	−0.4	0.1	−0.1	0.3	2.8
r^{AA25Y}	−2.3	−0.5	−0.1	−0.1	0.2	2.6
r^{AATM}	−3.0	−0.5	−0.1	−0.1	0.2	2.7

(*continued*)

Table 3.

Panel B: Correlations of understated PBOs and ABOs

	MC	*PCT_TB30Y*	*PCT_AAA20*	*PCT_AAA25*	*PCT_AAATM*	*PCT_AA20*	*PCT_AA25*	*PCT_AATM*
FS	0.83**	0.59**	0.61**	0.61**	0.61**	0.13**	0.16**	0.28**
MC		0.68**	0.69**	0.67**	0.65**	0.12**	0.19**	0.25**
PCT_TB30Y			0.99**	0.99**	0.97**	0.41**	0.46**	0.57**
PCT_AAA20Y				0.99**	0.98**	0.45**	0.50**	0.60**
PCT_AAA25Y					0.98**	0.42**	0.45**	0.56**
PCT_AAATM						0.42**	0.45**	0.61**
PCT_AA20Y							0.93**	0.87**
PCT_AA25Y								0.86**

	MC	*APCT_TB30Y*	*APCT_AAA20*	*APCT_AAA25*	*APCT_AAATM*	*APCT_AA20*	*APCT_AA25*	*APCT_AATM*
FS	0.83**	0.61**	0.62**	0.63**	0.63**	0.12**	0.15**	0.28**
MC		0.69**	0.70**	0.69**	0.66**	0.11**	0.18**	0.24**
APCT_TB30Y			0.99**	0.99**	0.97**	0.39**	0.44**	0.56**
APCT_AAA20Y				0.99**	0.98**	0.43**	0.47**	0.59**
APCT_AAA25Y					0.98**	0.40**	0.43**	0.55**
APCT_AAATM						0.39**	0.43**	0.60**
APCT_AA20Y							0.93**	0.87**
APCT_AA25Y								0.86**

Note(s): The sample covers 2,213 firm-year observations from January 1989 to December 2013. Panel A of the table provides summary statistics for understated pension liabilities in dollar amount and in percentage. The understated pension liabilities include understated PBOs and understated ABOs, relative to the following interest rate benchmarks: r^{TB30Y}, r^{AAA20Y}, r^{AAA25Y}, r^{AAATM}, r^{AA20Y}, r^{AA25Y} and r^{AATM}. The understated pension liabilities are scaled by the beginning of the fiscal year market value. The discount factor assumes a life expectancy of 15 years from retirement age of 65. Panel B tabulates pairwise correlations among various measures of understated PBOs and understated ABOs, respectively. ** indicates significance at the 5% level; * indicates significance at the 10% level are close, being \$335.6, \$352.1 and \$343.6 million, respectively, relative to r^{AAA20Y}, r^{AAA25Y} and r^{AAATM}. When we scale the understated PBOs by beginning of the fiscal year market value, PBOs are understated by 3.5% relative to the Treasury benchmark, and by 3.0%, 3.0% and 3.0%, respectively, relative to three AAA-grade corporate bond yield benchmarks. The understatements are large relative to Treasury bond and AAA-grade corporate yields but negligible relative to AA-grade corporate yields.

The patterns from understated ABOs essentially mirror those from PBOs. The average of the understated ABOs is \$359.3 million using r^{TB30Y} as the benchmark. The numbers become \$305.3, \$321.1 and \$315.1 million, respectively, relative to r^{AAA20Y}, r^{AAA25Y} and r^{AAATM}. As a percentage of the beginning of the fiscal year market value, ABOs are understated by 3.1% relative to the Treasury benchmark and by 2.6%, 2.7% and 2.7%, respectively, relative to three AAA-grade corporate bond yield benchmarks. Just as with PBOs, ABOs are significantly understated relative to Treasury bond and AAA-grade corporate bond yields, and understatements essentially disappear relative to AA-grade corporate bond yields.

Panel B of Table 3 summarizes the pairwise correlations among understated PBOs and ABOs. Almost all of the pairwise correlations are positive and highly significant. The understated PBOs relative to 30-year Treasury bond yields and AAA-grade corporate bond yields have the highest correlations. The same pattern is true for understated ABOs. Funded status and mandatory contributions are also significantly correlated with various measures of understated pension liabilities [20].

4.4 The determinants of corporate bond yield spreads

4.4.1 Explaining corporate bond yield spreads. We begin to examine the determination of corporate bond yield spreads by running the following OLS regressions using pooled time-series and cross-sectional data. Note we focus on the first bond issued by the firm in the fiscal year. Therefore, the time-series data are not consecutive in many cases because firms may not issue bonds in each fiscal year. The model is specified with the yield spread as the dependent variable and various yield spread determinants as independent variables:

$$SPREAD_{it} = \alpha_0 + \alpha_1 RATING_{it} + Z_{it} \bullet \alpha_2 + \alpha_3 FS_{it} + \alpha_4 MC_{it} + \alpha_5 USPL_{it} + \sum_{j=1}^{12} YD_j + \sum_{k=1}^{28} ID_k, \tag{5}$$

where $Z = [MAT\ OAMT\ COUP\ SENIOR\ FUNGIBLE\ TENDER\ INV\_GRD\ ME\_INF\ ASTD\ TB1Y\ TERM\ ED1\ TB3]$ refers to a vector of 12 control variables. $USPL_{it}$ denotes understated pension liabilities. The subscript i refers to debt issue i and t refers to fiscal year t. As discussed in earlier sections, the variables that help explain corporate bond yield spreads fall into the following categories: issue-specific features, firm-specific characteristics, macroeconomic variables and pension variables. We also include dummies for different calendar years and different industries. The variables of interest include *FS*, *MC* and understated pension liabilities. In Panel A of Table 4, we include *FS*, *MC* and seven variables that measure understated PBOs one at a time. In Panel B of Table 4, we include the corresponding seven variables that measure understated ABOs one at a time.

Pension variables are our primary focus. In Panel A of Table 4, we add pension variables one at a time. The estimated coefficients (t-statistics) on *FS* and *MC* are −0.010 (−2.84) and −0.188 (−4.58), respectively, when they are included separately. Borrowing costs are higher for firms with poorer funded status facing more mandatory contributions. The estimated coefficients on *PCT_TB30Y*, *PCT_AAA20*, *PCT_AAA25Y* and *PCT_AAATM* are −0.033

Table 4.
Explaining corporate bond yield spreads

Panel A: Funded status (*FS*), mandatory contributions (*MC*) and understated PBOs

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
RATING	−0.052 (−2.26)**	−0.050 (−2.16)**	−0.050 (−2.16)**	−0.050 (−2.18)**	−0.051 (−2.19)**	−0.050 (−2.17)**	−0.053 (−2.29)**	−0.052 (−2.26)**	−0.053 (−2.32)**
MAT	0.155 (11.78)**	0.155 (11.80)**	0.155 (11.78)**	0.155 (11.79)**	0.155 (11.78)**	0.155 (11.80)**	0.155 (11.80)**	0.155 (11.80)**	0.155 (11.81)**
OAMT	−0.098 (−1.36)	−0.110 (−1.54)	−0.107 (−1.49)	−0.106 (−1.48)	−0.106 (−1.48)	−0.102 (−1.43)	−0.090 (−1.26)	−0.091 (−1.27)	−0.092 (−1.28)
COUP	1.885 (9.85)**	1.895 (9.95)**	1.874 (9.83)**	1.871 (9.81)**	1.868 (9.79)**	1.867 (9.79)**	1.896 (9.93)**	1.900 (9.94)**	1.889 (9.89)**
SENIOR	−0.089 (−0.62)	−0.081 (−0.56)	−0.083 (−0.58)	−0.085 (−0.59)	−0.085 (−0.59)	−0.090 (−0.63)	−0.085 (−0.59)	−0.084 (−0.58)	−0.087 (−0.60)
FUNGIBLE	−0.265 (−3.55)**	−0.263 (−3.54)**	−0.258 (−3.50)**	−0.258 (−3.50)**	−0.259 (−3.52)**	−0.261 (−3.54)**	−0.253 (−3.39)**	−0.253 (−3.39)**	−0.256 (−3.44)**
TENDER	0.261 (2.56)**	0.264 (2.60)**	0.259 (2.54)**	0.258 (2.54)**	0.260 (2.55)**	0.256 (2.51)**	0.242 (2.35)**	0.241 (2.35)**	0.238 (2.32)**
INV_GRD	−0.432 (−3.16)**	−0.442 (−3.25)**	−0.449 (−3.29)**	−0.447 (−3.28)**	−0.445 (−3.27)**	−0.443 (−3.25)**	−0.468 (−3.40)**	−0.468 (−3.40)**	−0.466 (−3.40)**
ME_INF	0.007 (0.18)	0.015 (0.34)	0.010 (0.24)	0.011 (0.25)	0.010 (0.23)	0.007 (0.16)	0.005 (0.13)	0.006 (0.13)	0.008 (0.18)
ASTD	0.916 (6.58)**	0.898 (6.46)**	0.928 (6.73)**	0.927 (6.72)**	0.928 (6.73)**	0.940 (6.82)**	0.977 (7.00)**	0.978 (7.01)**	0.972 (6.98)**
TB1Y	−0.548 (−7.69)**	−0.555 (−7.83)**	−0.518 (−7.29)**	−0.519 (−7.32)**	−0.516 (−7.26)**	−0.520 (−7.33)**	−0.541 (−7.27)**	−0.539 (−7.26)**	−0.522 (−7.09)**
TERM	−0.662 (−8.30)**	−0.679 (−8.54)**	−0.625 (−7.84)**	−0.628 (−7.88)**	−0.624 (−7.82)**	−0.628 (−7.87)**	−0.644 (−7.89)**	−0.646 (−7.98)**	−0.631 (−7.78)**
ED1TB3	−0.119 (−2.12)**	−0.113 (−2.02)**	−0.140 (−2.62)**	−0.139 (−2.59)**	−0.140 (−2.62)**	−0.138 (−2.56)**	−0.143 (−2.58)**	−0.135 (−2.45)**	−0.140 (−2.56)**
FS	−0.010 (−2.84)**								
MC		−0.188 (−4.58)**							
PCT_TB30Y			−0.033 (−4.64)**						
PCT_AAA20Y				−0.038 (−4.62)**					
PCT_AAA25Y					−0.036 (−4.62)**				
PCT_AAATM						−0.033 (−4.36)**			
PCT_AA20Y							−0.020 (−0.76)		
PCT_AA25Y								−0.021 (−0.77)	
PCT_AATM									−0.039 (−1.76)*
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.642	0.644	0.644	0.644	0.644	0.644	0.641	0.641	0.641
Observations	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213

Panel B: Understated ABOs

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
RATING	−0.049 (−2.11)**	−0.049 (−2.13)**	−0.050 (−2.16)**	−0.049 (−2.14)**	−0.053 (−2.29)**	−0.052 (−2.27)**	−0.054 (−2.32)**
MAT	0.155 (11.78)**	0.155 (11.79)**	0.155 (11.78)**	0.155 (11.80)**	0.155 (11.80)**	0.155 (11.80)**	0.155 (11.82)**
OAMT	−0.108 (−1.51)	−0.107 (−1.49)	−0.107 (−1.49)	−0.103 (−1.44)	−0.090 (−1.26)	−0.091 (−1.27)	−0.092 (−1.28)
COUP	1.872 (9.82)**	1.869 (9.80)**	1.866 (9.78)**	1.866 (9.78)**	1.896 (9.93)**	1.899 (9.94)**	1.888 (9.89)**
SENIOR	−0.090 (−0.63)	−0.093 (−0.64)	−0.091 (−0.63)	−0.097 (−0.67)	−0.086 (−0.59)	−0.084 (−0.58)	−0.089 (−0.62)
FUNIGIBLE	−0.259 (−3.52)**	−0.259 (−3.52)**	−0.260 (−3.53)**	−0.262 (−3.55)**	−0.253 (−3.39)**	−0.253 (−3.39)**	−0.256 (−3.45)**
TENDER	0.260 (2.56)**	0.260 (2.56)**	0.262 (2.58)**	0.257 (2.53)**	0.242 (2.36)**	0.241 (2.35)**	0.239 (2.33)**
INV_GRD	−0.451 (−3.31)**	−0.449 (−3.30)**	−0.447 (−3.29)**	−0.445 (−3.26)**	−0.469 (−3.40)**	−0.469 (−3.41)**	−0.467 (−3.40)**
ME_INF	0.009 (0.21)	0.010 (0.23)	0.009 (0.21)	0.006 (0.14)	0.006 (0.13)	0.006 (0.14)	0.008 (0.19)

(*continued*)

Panel B: Understated ABOs

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
ASTD	0.924 (6.71)**	0.924 (6.70)**	0.924 (6.70)**	0.936 (6.80)**	0.976 (7.00)**	0.977 (7.01)**	0.970 (6.97)**
TB1Y	−0.515 (−7.24)**	−0.517 (−7.28)**	−0.514 (−7.22)**	−0.518 (−7.30)**	−0.540 (−7.26)**	−0.539 (−7.25)**	−0.522 (−7.07)**
TERM	−0.622 (−7.80)**	−0.626 (−7.86)**	−0.622 (−7.79)**	−0.626 (−7.85)**	−0.644 (−7.88)**	−0.645 (−7.97)**	−0.631 (−7.77)**
ED1TB3	−0.141 (−2.64)**	−0.140 (−2.61)**	−0.141 (−2.64)**	−0.139 (−2.58)**	−0.143 (−2.59)**	−0.135 (−2.45)**	−0.141 (−2.57)**
APCT_TB30Y	−0.038 (−4.86)**						
APCT_AAA20Y		−0.044 (−4.88)**					
APCT_AAA25Y			−0.042 (−4.84)**				
APCT_AAATM				−0.038 (−4.57)**			
APCT_AA20Y					−0.023 (−0.78)		
APCT_AA25Y						−0.024 (−0.80)	
APCT_AATM							−0.043 (−1.78)*
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.644	0.644	0.644	0.644	0.641	0.641	0.641
Observations	2,213	2,213	2,213	2,213	2,213	2,213	2,213

Panel C: Incremental predictive power of *FS*, *MC* and understated pension liabilities

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
RATING	−0.048 (−2.10)**	−0.049 (−2.11)**	−0.049 (−2.12)**	−0.048 (−2.09)**	−0.048 (−2.06)**	−0.048 (−2.08)**	−0.048 (−2.09)**	−0.048 (−2.07)**
MAT	0.155 (11.78)**	0.155 (11.78)**	0.155 (11.78)**	0.155 (11.79)**	0.155 (11.78)**	0.155 (11.78)**	0.155 (11.78)**	0.155 (11.79)**
OAMT	−0.115 (−1.60)	−0.114 (−1.59)	−0.115 (−1.60)	−0.113 (−1.58)	−0.116 (−1.61)	−0.115 (−1.60)	−0.115 (−1.60)	−0.113 (−1.58)
COUP	1.887 (9.85)**	1.885 (9.83)**	1.883 (9.81)**	1.883 (9.83)**	1.885 (9.84)**	1.883 (9.82)**	1.881 (9.81)**	1.882 (9.82)**
SENIOR	−0.078 (−0.54)	−0.079 (−0.55)	−0.079 (−0.55)	−0.082 (−0.57)	−0.083 (−0.57)	−0.085 (−0.59)	−0.083 (−0.58)	−0.087 (−0.60)
FUNGIBLE	−0.257 (−3.46)**	−0.257 (−3.45)**	−0.258 (−3.46)**	−0.259 (−3.48)**	−0.258 (−3.47)**	−0.257 (−3.46)**	−0.257 (−3.47)**	−0.259 (−3.49)**
TENDER	0.261 (2.57)**	0.261 (2.57)**	0.262 (2.58)**	0.260 (2.56)**	0.262 (2.58)**	0.262 (2.58)**	0.263 (2.59)**	0.261 (2.56)**
INV_GRD	−0.455 (−3.36)**	−0.454 (−3.36)**	−0.453 (−3.36)**	−0.452 (−3.35)**	−0.457 (−3.38)**	−0.457 (−3.38)**	−0.456 (−3.37)**	−0.454 (−3.36)**
ME_INF	0.015 (0.36)	0.015 (0.37)	0.015 (0.36)	0.014 (0.32)	0.014 (0.34)	0.015 (0.34)	0.014 (0.33)	0.013 (0.30)
ASTD	0.912 (6.59)**	0.913 (6.60)**	0.914 (6.60)**	0.919 (6.63)**	0.912 (6.59)**	0.913 (6.60)**	0.914 (6.60)**	0.919 (6.63)**
TB1Y	−0.534 (−7.45)**	−0.534 (−7.47)**	−0.532 (−7.43)**	−0.536 (−7.51)**	−0.531 (−7.39)**	−0.531 (−7.43)**	−0.529 (−7.37)**	−0.534 (−7.47)**
TERM	−0.651 (−8.13)**	−0.652 (−8.16)**	−0.649 (−8.10)**	−0.655 (−8.20)**	−0.647 (−8.07)**	−0.649 (−8.11)**	−0.646 (−8.06)**	−0.652 (−8.17)**
ED1TB3	−0.130 (−2.39)**	−0.130 (−2.39)**	−0.131 (−2.41)**	−0.128 (−2.33)**	−0.132 (−2.42)**	−0.132 (−2.42)**	−0.133 (−2.44)**	−0.130 (−2.37)**
FS	0.007 (1.10)	0.007 (1.16)	0.007 (1.19)	0.008 (1.28)	0.007 (1.12)	0.007 (1.19)	0.008 (1.24)	0.008 (1.32)
MC	−0.166 (−2.03)**	−0.164 (−1.99)**	−0.168 (−2.07)**	−0.187 (−2.40)**	−0.160 (−1.93)*	−0.158 (−1.90)*	−0.163 (−2.00)**	−0.183 (−2.34)**
PCT_TB30Y	−0.023 (−2.34)**							
PCT_AAA20Y		−0.027 (−2.38)**						
PCT_AAA25Y			−0.026 (−2.40)**					
PCT_AAATM				−0.023 (−2.31)**				
APCT_TB30Y					−0.028 (−2.44)**			

(*continued*)

Table 4.

Table 4.

Panel C: Incremental predictive power of *FS*, *MC* and understated pension liabilities

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
APCT_AAA20Y						−0.033 (−2.52)**		
APCT_AAA25Y							−0.032 (−2.55)**	
APCT_AAATM								−0.027 (−2.44)**
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.644	0.644	0.644	0.644	0.644	0.645	0.645	0.644
Observations	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213

Note(s): The sample covers 2,213 firm-year observations from January 1989 to December 2013. The table provides OLS regressions of corporate bond yield spreads on variables belonging to the following categories: issue characteristics, firm characteristics, macroeconomic variables and pension variables. Issue characteristics include S&P debt rating (*RATING*), maturity (*MAT*), offered amount (*OAMT*), coupon rate (*COUP*), dummy variable for debt security level that is equal to seniority (*SENIOR*), dummy variable for debt issue that is fungible (*FUNGIBLE*), dummy variable for debt issued under tender or exchange offer (*TENDER*) and dummy variable for investment grade bond (*INV_GRD*). Firm characteristics include inflation-adjusted market value in constant 2013 US billion $ (*ME_INF*) and time-trend–adjusted residual standard deviations (*ASTD*) within each fiscal year. Macroeconomic variables include one-year Treasury note yield (*TB1Y*), term premium calculated as the difference between 10-year and one-year Treasury note yields (*TERM*), and Eurodollar premium calculated as the difference between the one-month Eurodollar rate and three-month Treasury bill rate (*ED1TB3*). Pension variables include funded status (*FS*), mandatory contributions (*MC*) and understated PBOs and ABOs relative to alternative interest rate benchmarks. Panel A adds understated PBOs (*PCT_TB30Y*, *PCT_AAA20Y*, *PCT_AAA25Y*, *PCT_AAATM*, *PCT_AA20Y*, *PCT_AA25Y*, *PCT_AATM*) in the regressions; Panel B adds understated ABOs (*APCT_TB30Y*, *APCT_AAA20Y*, *APCT_AAA25Y*, *APCT_AAATM*, *APCT_AA20Y*, *APCT_AA25Y*, *APCT_AATM*) in the regressions. Panel C examines the incremental predictive power of *FS*, *MC* and understated PBOs or ABOs. Definitions of the variables are provided in Appendix 1. Corporate bond yield spreads (*SPREAD*) are the difference between corporate debt yield at issue and the corresponding AAA-grade corporate debt yield of the closest maturity. S&P debt ratings are numbered from 22 for AAA to 1 for D. ** indicates significance at the 5% level; * indicates significance at the 10% level. Petersen (2009) two dimension firm and year clustered *t*-statistics are reported

(−4.64), −0.038 (−4.62), −0.036 (−4.62) and −0.033 (−4.36), respectively. Relative to AA-grade corporate bond yields, understated PBOs are not significant. In Panel B of Table 4, we add understated ABOs one at a time. The estimated coefficients on *APCT_TB30Y*, *APCT_AAA20Y*, *APCT_AAA25Y* and *APCT_AAATM* are −0.038 (−4.86), −0.044 (−4.88), −0.042 (−4.84) and −0.038 (−4.57), respectively. These negative coefficients indicate that when understated pension liabilities are negative and large in absolute value, the yield spread will be higher. Therefore, although firms have latitude in choosing pension discount rates higher than benchmark interest rates to lower their reported pension liabilities, debt market investors well understand that firms try to hide pension obligations that are off the balance sheet and adjust firms' borrowing costs upward accordingly.

Among the following standard control variables that explain corporate bond yield spreads, RATING, MAT, OAMT, COUP, SENIOR, FUNGIBLE, TENDER, INV_GRD, ME_INF, ASTD, TB1Y, *TERM* and *ED1TB3*, nine are highly significant with the expected signs. Corporate bond yield spreads are significantly positively related to *MAT*, *COUP*, *TENDER* and *ASTD* and significantly negatively related to *RATING, FUNGIBLE, INV_GRD*, *TB1Y* and *TERM*.

Our results are broadly consistent with the existing literature. Credit rating (*RATING*), maturity (*MAT*), coupon rate (*COUP*), investment grade (*INV_GRD*), residual standard deviation (*ASTD*), one-year Treasury note yield (*TB1Y*) and term-premium (*TERM*) are the primary determinants of corporate bond yield spreads with large *t*-statistics. We also examine whether accounting ratios such as coverage ratio (*COVERAGE*), profit margin (*MARGIN*), long-term leverage (*LLEV*) and proportion of fixed assets (*PPE*) can help explain corporate bond yield spreads. It turns out that once credit rating is included, these accounting ratios are not significant.

4.4.2 Marginal predictive power and FS, MC *and understated pension liabilities.* Pension variables are highly correlated. For example, *FS* and *MC* have a high correlation of 0.83 from Panel B of Table 1. According to Panel B of Table 3, the correlations between *FS* and understated pension liabilities *PCT_TB30Y* and *APCT_TB30Y* are 0.59 and 0.61, respectively. The correlations between *MC* and understated pension liabilities *PCT_TB30Y* and *APCT_TB30Y* are 0.68 and 0.69, respectively. This is not surprising because firms with better funded status tend to face less mandatory contributions. There is less need for these firms to hide some of their pension liabilities by choosing a higher pension discount rate. This raises the issue of whether these pension variables are capturing the same financial health of firms' pension plans. We address this issue in Panel C of Table 4 which includes *FS*, *MC* and understated PBOs and ABOs together. We only consider understated PBOs and ABOs relative to 30-year Treasury bond yields and AAA-grade corporate bond yields because, from Panels A and B of Table 4, understated PBOs and ABOs relative to AA-grade corporate bond yields do not have explanatory power on corporate yield spreads.

From Panel C of Table 4, the estimated coefficient on *FS* becomes insignificant. The conclusion is valid for all eight model specifications in which we use alternative measures of understated PBOs and ABOs. Therefore, mandatory contributions and understated pension liabilities have significant incremental explanatory power for corporate bond yield spreads.

Now we examine the economic significance of mandatory contributions and understated pension liabilities from the estimated slope coefficients in Eqn (5). First, from Panel A of Table 1, the 25th and 75th percentile values of mandatory contributions are −0.708 and 0.001%, respectively, from our pooled sample. From Panel A of Table 3, the 25th and 75th percentile values of understated PBO relative to 30-year Treasury bond yields (*PCT_TB30Y*) are −4.3% and −0.6%, respectively. The 25th and 75th percentile values of understated ABO relative to 30-year Treasury bond yields (*APCT_TB30Y*) are −3.8% and −0.5%, respectively.

Second, Panel C of Table 4 shows that the estimated coefficient (t-statistic) on *MC* is −0.166 (−2.03). The estimated coefficient (t-statistic) on *PCT_TB30Y* is −0.023 (−2.34), while the estimated coefficient (t-statistic) on *APCT_TB30Y* is −0.028 (−2.44).

Therefore, in moving from the 25th percentile value to the 75th percentile value in our pooled sample, the incremental impact on firms' costs of borrowing or yield spreads is $0.166 \times (0.708 + 0.001)$ or 0.118% from mandatory contributions. The incremental impacts are 0.023(4.3–0.6) or 0.085% and $0.028 \times (3.8–0.5)$ or 0.092%, respectively, from understated PBOs and ABOs relative to long-term Treasury bond yields. These numbers translate into 11.8, 8.5 and 9.2 basis point increases in firms' costs of borrowing, respectively. We reach similar conclusions when interest rate benchmarks are long-term AAA- or AA-grade corporate bond yields.

4.4.3 Investment grade and non-investment grade bonds. In this section, we aim to answer the question of whether our strong results on understated pension liabilities are driven by investment grade bonds or non-investment grade bonds. Among the sample of 2,213 bonds issued during the 1989–2013 period, a total of 1,684 bonds belong to the category of investment grade bonds with S&P debt ratings of BBB- or above. In the regression Eqn (5), we add an interactive term *INV_GRD* × *USPL* to capture the differential effects of understated pension liabilities on corporate bond yield spreads between investment and non-investment grade bonds. For simplicity, we only report the estimation results on the following five variables in Table 5: *FS*, *MC*, *USPL*, *INV_GRD* × *USPL* and *INV_GRD*, where *USPL* refers to the four understated PBOs and four understated ABOs as in previous tables.

From Model 1 of Table 5, the estimated coefficient (t-stat.) on *PCT_TB30Y* is −0.038 (−3.07), while the estimate (t-stat.) on the interactive term *PCT_TB30Y* × *INV_GRD* is 0.028 (2.16). In other words, the impact of *PCT_TB30Y* from investment grade bonds on their yield spreads is much smaller. Roughly speaking, the impact is equal to the summation of the two coefficients, or $-0.038 + 0.028 = -0.010$. The strong effects of understated pension liabilities on corporate bond yield spreads are driven by non-investment grade bonds. This conclusion is valid for all other measures of understated PBOs and understated ABOs.

Interestingly, our results on understated pension liabilities closely mirror those from Rauh (2006) and Campbell *et al.* (2012). Rauh (2006) finds that the negative association between mandatory pension contributions and firm investment levels is particularly evident among firms facing external financing constraints, as proxied by low credit ratings. Campbell *et al.* (2012) report that the association between mandatory pension contributions and cost of debt will be stronger for firms facing greater external financing constraints. All of this evidence is consistent with the story that the market frictions that cause external funds to be more expensive than internal funds will be larger for firms facing greater external financing constraints (Almeida *et al.*, 2004; Rauh, 2006; Franzoni, 2009; among others). Firms facing financial constraints incur higher costs when they issue external debt or equity [21].

4.5 Instrumental variable estimates

4.5.1 First-stage analysis. Corporate bond yield spreads and S&P debt ratings are jointly determined and influence each other. Earlier studies document that debt ratings affect yield spreads and have incremental explanatory power after controlling for firms' financial ratios (West, 1973). More recently, Kliger and Sarig (2000) and Tang (2009) examine the impact of Moody's 1986 refined rating on cost of debt. Kisgen and Strahan (2010) investigate the impact of bond rating–related regulation changes on corporate borrowing costs. Bongaerts *et al.*, (2012) study yield spread reaction to bond rating changes issued by S&P, Moody and Fitch to test three alternative hypotheses regarding multiple ratings. On the other hand, rating agencies also take into account the impact of business cycle and macroeconomic information when assigning a debt rating (Standard and Poor's, 2006). Macroeconomic factors most relevant to corporate

Table 5. Investment grade bonds and understated pension liabilities

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
FS	0.009 (1.49)	0.010 (1.55)	0.010 (1.61)	0.010 (1.61)	0.010 (1.52)	0.010 (1.59)	0.010 (1.64)	0.010 (1.63)
MC	−0.174 (−2.13)**	−0.171 (−2.08)**	−0.176 (−2.18)**	−0.197 (−2.53)**	−0.169 (−2.04)**	−0.166 (−2.00)**	−0.173 (−2.13)**	−0.193 (−2.47)**
PCT_TB30Y	−0.038 (−3.07)**							
PCT_TB30Y × *INV_GRD*	0.028 (2.16)**							
INV_GRD	−0.325 (−2.19)**							
PCT_AAA20Y		−0.045 (−3.20)**						
PCT_AAA20Y × *INV_GRD*		0.034 (2.22)**						
INV_GRD		−0.320 (−2.16)**						
PCT_AAA25Y			−0.045 (−3.27)**					
PCT_AAA25Y × *INV_GRD*			0.035 (2.34)**					
INV_GRD			−0.313 (−2.11)**					
PCT_AAATM				−0.037 (−3.00)**				
PCT_AAATM × *INV_GRD*				0.028 (2.02)**				
INV_GRD				−0.336 (−2.27)**				
APCT_TB30Y					−0.044 (−3.17)**			
APCT_TB30Y × *INV_GRD*					0.032 (2.20)**			
INV_GRD					−0.325 (−2.19)**			
APCT_AAA20Y						−0.053 (−3.35)**		
APCT_AAA20Y × *INV_GRD*						0.038 (2.27)**		
INV_GRD						−0.321 (−2.16)**		
APCT_AAA25Y							−0.051 (−3.33)**	
APCT_AAA25Y × *INV_GRD*							0.037 (2.29)**	
INV_GRD							−0.320 (−2.16)**	
APCT_AAATM								−0.042 (−3.03)**
APCT_AAATM × *INV_GRD*								0.029 (1.93)*
INV_GRD								−0.344 (−2.32)**
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.645	0.645	0.645	0.645	0.645	0.645	0.645	0.645
Observations	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213

Note(s): The sample covers 2,213 firm-year observations from January 1989 to December 2013. The table examines the impact of understated pension liabilities on corporate bond yield spreads from investment grade and non-investment grade bonds. The table only reports the estimated coefficients on *FS*, *MC*, understated PBOs (ABOs), an interactive term of understated PBOs (ABOs) with a dummy for investment grade bond (*INV_GRD*) and a dummy for investment grade bond (*INV_GRD*). The table controls for variables that belong to the following categories: issue characteristics, firm characteristics, macroeconomic variables and pension variables as defined in previous tables. Understated PBOs include *PCT_TB30Y*, *PCT_AAA20Y*, *PCT_AAA25Y* and *PCT_AAATM*. Understated ABOs include *APCT_TB30Y*, *APCT_AAA20Y*, *APCT_AAA25Y* and *APCT_AAATM*. Definitions of the variables are provided in Appendix 1. Corporate bond yield spreads (*SPREAD*) are the difference between corporate debt yield at issue and the corresponding AAA-grade corporate debt yield of the closest maturity. S&P debt ratings are numbered from 22 for AAA to 1 for D. ** indicates significance at the 5% level; * indicates significance at the 10% level. Petersen's (2009) two-dimensional firm and year clustered *t*-statistics are reported credit rating include interest rate trends and corporate bond yield spreads. In addition to the joint determination of yield spreads and debt ratings, pension discount rates are also decision variables. We documented earlier that firms have a lot of discretion in choosing their pension discount rates and deviate significantly from the stipulated benchmark interest rates. Therefore, there is an endogeneity issue with respect to the significant negative relation between corporate bond yield spreads and understated pension liabilities.

When an endogenous variable is used as one of the independent variables, the estimated coefficient will, in general, be biased. To correct for potential biases in the OLS estimates due to the endogeneity of *RATING* and *USPL* in Eqn (5) for *SPREAD*, we use 2SLS instrumental variable (IV) estimators, replacing the original *RATING* and *USPL* with their instrumented or predicted values. We now specify a system of three equations for *SPREAD*, *RATING* and *USPL* as follows:

$$SPREAD_{i,t} = \alpha_0 + \alpha_1 RATING_{i,t} + \alpha_2 USPL_{i,t} + Z_{i,t} \bullet \alpha + \sum_{j=1}^{12} YD_j + \sum_{k=1}^{28} ID_k + \varepsilon_{\mathrm{i,t}}, \tag{6}$$

$$RATING_{i,t} = \beta_0 + \beta_1 SPREAD_{i,t} + \beta_2 USPL_{i,t} + Z_{i,t} \bullet \beta + \sum_{j=1}^{12} YD_j + \sum_{k=1}^{28} ID_k + \varepsilon_{\mathrm{i,t}}, \tag{7}$$

$$USPL_{i,t} = \gamma_0 + \gamma_1 SPREAD_{i,t} + \gamma_2 RATING_{i,t} + Z_{i,t} \bullet \gamma + \sum_{j=1}^{12} YD_j + \sum_{k=1}^{28} ID_k + \varepsilon_{\mathrm{i,t}}, \tag{8}$$

where Z = [*MAT OAMT COUP SENIOR FUNGIBLE TENDER INV_GRD ME_INF COVERAGE MARGIN LLEV PPE ASTD TB1Y TERM ED1TB3 FS MC*] refers to a vector of 18 control variables. *USPL* refers to understated PBOs (*PCT_TB30Y*, *PCT_AAA20Y*, *PCT_AAA25Y*, *PCT_AAATM*) and understated ABOs (*PCT_TB30Y*, *PCT_AAA20Y*, *PCT_AAA25Y*, *PCT_AAATM*), respectively. $\alpha = [\alpha_3, \ \ldots, \alpha_{20}]'$, $\beta = [\beta_3, \ \ldots, \beta_{20}]'$ and $\gamma = [\gamma_3, \ \ldots, \gamma_{20}]'$ are three vectors of parameters to be estimated.

Before performing the 2SLS analysis, we wish to analyze the strength of the instruments in the first stage. If the instruments are "weak," in the sense of having low correlation with the endogenous variable or insignificant OLS coefficients in the first-stage reduced form regression that only includes exogenous variables, then the IV coefficient estimates are biased. The *F*-statistic provides a useful measure for the strength of the explanatory variables to serve as instruments. Stock and Yogo (2005) and Stock *et al.* (2002) report that for a test of whether the 2SLS bias is less than 10% of the OLS bias, they estimate the critical value *F*-statistic to be 8.96 when testing the strength of one instrument. This is equivalent to a *t*-statistic of 3.00 in absolute value.

We summarize the first stage diagnostic for *SPREAD* and *RATING* in Panel A of Table 6. Based on the *F*-statistics, we confirm that *MAT*, *COUP*, *FUNGIBLE*, *INV_GRD*, *ASTD*, *TB1Y* and *TERM* serve as strong instruments for *SPREAD*. On the other hand, *MAT*, *OAMT*, *COUP*, *SENIOR*, *INV_GRD*, *ME_INF*, *COVERAGE*, *MARGIN*, *LLEV*, *PPE* and *ASTD* serve as strong instruments for *RATING*.

Panel B of Table 6 summarizes the first stage diagnostic for understated PBOs. For all four measures of understated PBOs, *COVERAGE*, *MARGIN*, *TB1Y* and *MC* serve as strong instruments. Likewise, Panel C shows that for all four measures of understated ABOs, the same set of variables serve as strong instruments. In principle, understated pension liability is most severe when a firm's interest coverage is inadequate, their profit margin is low and they face more mandatory contributions. It is particularly interesting to note that the yield on one-year Treasury notes also turns out to be strongly related to understated pension liabilities. Firms tend to hide more when the one-year interest rate is low and hide less when

Table 6. Diagnosis of model specification: Strength of instrumental variables in 2SLS

Panel A: The dependent variables are *SPREAD* and *RATING*

Exogenous variable	*SPREAD* F-statistic (p-value)	*RATING* F-statistic (p-value)
MAT	140.21 (0.00)***	19.65 (0.00)***
OAMT	3.15 (0.08)	15.66 (0.00)***
COUP	100.92 (0.00)***	33.18 (0.00)***
SENIOR	0.58 (0.45)	9.58 (0.00)***
FUNGIBLE	13.05 (0.00)***	0.32 (0.57)
TENDER	6.71 (0.01)	0.47 (0.50)
INV_GRD	22.75 (0.00)***	935.26 (0.00)***
ME_INF	0.22 (0.64)	204.46 (0.00)***
COVERAGE	2.53 (0.11)	27.47 (0.00)***
MARGIN	1.80 (0.18)	15.36 (0.00)***
LLEV	4.32 (0.04)	145.52 (0.00)***
PPE	0.95 (0.33)	10.47 (0.00)***
ASTD	46.31 (0.00)***	38.52 (0.00)***
TB1Y	60.20 (0.00)***	0.49 (0.49)
TERM	72.94 (0.00)***	5.49 (0.02)
ED1TB3	4.70 (0.03)	0.22 (0.64)
FS	0.47 (0.49)	1.09 (0.30)
MC	8.74 (0.00)	0.77 (0.38)
Year dummies	Yes	Yes
Industry dummies	Yes	Yes
R^2	0.644	0.817
Observations	2,213	2,213

Panel B: The dependent variables are *UPBO*s

Exogenous variable	*PCT_TB30Y* F-statistic (p-value)	*PCT_AAA20Y* F-statistic (p-value)	*PCT_AAA25Y* F-statistic (p-value)	*PCT_AAATM* F-statistic (p-value)
MAT	1.81 (0.18)	2.39 (0.12)	2.44 (0.12)	4.14 (0.04)
OAMT	0.84 (0.36)	0.43 (0.51)	0.54 (0.46)	0.19 (0.66)
COUP	3.59 (0.06)	4.56 (0.03)	6.22 (0.01)	6.25 (0.01)
SENIOR	0.29 (0.59)	0.15 (0.69)	0.13 (0.72)	0.01 (0.91)
FUNGIBLE	0.15 (0.70)	0.21 (0.65)	0.13 (0.72)	0.01 (0.92)
TENDER	0.00 (0.95)	0.00 (0.97)	0.04 (0.85)	0.03 (0.85)

(*continued*)

Table 6.

Panel B: The dependent variables are *UPBO*s

Exogenous variable	*PCT_TB30Y* F-statistic (*p*-value)	*PCT_AAA20Y* F-statistic (*p*-value)	*PCT_AAA25Y* F-statistic (*p*-value)	*PCT_AAATM* F-statistic (*p*-value)
INV_GRD	0.09 (0.76)	0.07 (0.80)	0.05 (0.82)	0.59 (0.44)
ME_INF	0.17 (0.68)	0.20 (0.66)	0.03 (0.85)	0.09 (0.77)
COVERAGE	14.96 (0.00)***	13.74 (0.00)***	14.27 (0.00)***	18.39 (0.00)***
MARGIN	10.02 (0.00)***	9.30 (0.00)***	9.47 (0.00)***	5.94 (0.01)
LLEV	4.82 (0.03)	4.93 (0.03)	4.79 (0.03)	7.31 (0.01)
PPE	0.00 (0.98)	0.01 (0.91)	0.06 (0.81)	0.09 (0.76)
ASTD	0.09 (0.76)	0.17 (0.68)	0.29 (0.59)	1.06 (0.30)
TB1Y	49.87 (0.00)***	46.73 (0.00)***	53.76 (0.00)***	44.70 (0.00)***
TERM	47.70 (0.00)***	45.18 (0.00)***	48.84 (0.00)***	38.77 (0.00)***
ED1TB3	8.34 (0.00)	7.84 (0.01)	8.12 (0.00)	7.38 (0.01)
FS	5.68 (0.02)	7.60 (0.01)	9.72 (0.00)***	17.44 (0.00)***
MC	79.08 (0.00)***	73.66 (0.00)***	68.30 (0.00)***	36.08 (0.00)***
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
R^2	0.543	0.549	0.541	0.519
Observations	2,213	2,213	2,213	2,213

Panel C: The dependent variables are *UABO*s

Exogenous variable	*APCT_TB30Y* F-statistic (*p*-value)	*APCT_AAA20Y* F-statistic (*p*-value)	*APCT_AAA25Y* F-statistic (*p*-value)	*APCT_AAATM* F-statistic (*p*-value)
MAT	2.21 (0.14)	2.88 (0.09)	2.96 (0.09)	4.73 (0.03)
OAMT	1.37 (0.24)	0.74 (0.39)	0.81 (0.37)	0.39 (0.53)
COUP	4.20 (0.04)	5.38 (0.02)	6.60 (0.01)	6.44 (0.01)
SENIOR	0.00 (0.98)	0.03 (0.85)	0.00 (0.98)	0.16 (0.69)
FUNGIBLE	0.11 (0.74)	0.20 (0.66)	0.12 (0.73)	0.00 (0.95)
TENDER	0.05 (0.83)	0.01 (0.91)	0.12 (0.73)	0.01 (0.94)
INV_GRD	0.11 (0.74)	0.07 (0.79)	0.06 (0.80)	0.66 (0.42)
ME_INF	0.03 (0.86)	0.07 (0.79)	0.00 (0.95)	0.17 (0.68)
COVERAGE	20.27 (0.00)***	18.40 (0.00)***	18.59 (0.00)***	21.71 (0.00)***
MARGIN	9.13 (0.00)***	8.60 (0.00)	8.23 (0.00)	5.26 (0.02)
LLEV	5.54 (0.02)	5.65 (0.02)	5.64 (0.02)	7.93 (0.00)
PPE	0.09 (0.77)	0.15 (0.69)	0.20 (0.65)	0.00 (0.95)

(*continued*)

Panel C: The dependent variables are *UABOs*

Exogenous variable	*APCT_TB30Y* F-statistic (*p*-value)	*APCT_AAA20Y* F-statistic (*p*-value)	*APCT_AAA25Y* F-statistic (*p*-value)	*APCT_AAATM* F-statistic (*p*-value)
ASTD	0.03 (0.86)	0.10 (0.76)	0.12 (0.73)	0.70 (0.40)
TB1Y	58.51 (0.00)***	51.88 (0.00)***	58.89 (0.00)***	48.26 (0.00)***
TERM	52.08 (0.00)***	47.77 (0.00)***	50.39 (0.00)***	40.13 (0.00)***
ED1TB3	9.85 (0.00)***	9.23 (0.00)***	9.07 (0.00)***	8.85 (0.00)
FS	6.06 (0.01)	8.10 (0.00)	10.76 (0.00)***	18.31 (0.00)***
MC	83.05 (0.00)***	76.25 (0.00)***	67.20 (0.00)***	36.75 (0.00)***
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
R^2	0.570	0.571	0.562	0.540
Observations	2,213	2,213	2,213	2,213

Note(s): The sample covers 2,213 firm-year observations from January 1989 to December 2013. This table provides diagnostics for model specification and instrumental variables in a 2SLS regression. The three structural equations are (1) *SPREAD* = linear function (*RATING*, *USPLs*, *Z*); (2) *RATING* = linear function (*SPREAD*, *USPLs*, *Z*); and (3) *USPLs* = linear function (*SPREAD*, *RATING*, *Z*), where *SPREAD* refers to the difference between corporate debt yield at issue and the corresponding AAA-grade corporate debt yield of the closest maturity. *RATING* refers to S&P credit rating. *USPLs* refers to understated PBOs (*UPBOs*) and understated ABOs (*UABOs*). *Z* is the set of exogenous variables, including the constant intercept, *MAT*, *OAMT*, *COUP*, *SENIOR*, *FUNGIBLE*, *TENDER*, *INV_GRD*, *ME_INF*, *COVERAGE*, *MARGIN*, *LLEV*, *PPE*, *ASTD*, *TB1Y*, *TERM*, *ED1TB3*, *FS*, *MC*, year dummies and industry dummies. In Panel A, *SPREAD* and *RATING* are regressed on *Z*. In Panels B and C, *UPBOs* and *UABOs* are regressed on *Z*, respectively. The understated PBOs relative to four interest rate benchmarks (*PCT_TB30Y*, *PCT_AAA20Y*, *PCT_AAA25Y*, *PCT_AAATM*) and understated ABOs (*APCT_TB30Y*, *APCT_AAA20Y*, *APCT_AAA25Y*, *APCT_AAATM*) are scaled by the beginning of the fiscal year market value *ME(–1)*. The table reports the *F*-statistic tests for the significance of the coefficient on the exogenous variable. *** indicates *F*-statistic is larger than 8.96

Table 6.

the one-year interest rate is high. This is driven by two facts. First, the interest rate drops during the sample period 1989–2013. Second, firms lower their pension discount rates in response to changes in interest rate benchmarks by less than one for one (Panel B of Table 2). Therefore, the gap between pension discount rates and interest rate benchmarks is wider in later years of the sample when interest rates have dropped significantly (Figure 2). The wider gap corresponds to more severe understated pension liabilities.

4.5.2 Second-stage analysis. We summarize the 2SLS results in Table 7. In the 2SLS estimation, Eqns (6)–(8) are estimated separately. We first look at Model 1 in Panel A in which we use *PCT_TB30Y* to measure understated PBOs. In the equation explaining *SPREAD*, the estimates on the control variables are essentially the same as the OLS results. The estimate (*t*-stat.) for the instrumented *RATING* is −0.225 (−3.37). Therefore, debt rating affects corporate bond yield spreads. The estimate (*t*-stat.) for the instrumented *PCT_TB30Y* is −0.047 (−4.15). This is the key result. The evidence again provides strong support for our hypothesis that debt market investors see through managers' attempts to hide their pension obligations and adjust firms' borrowing costs accordingly. The overidentifying restrictions test statistic is 1.51 with a *p*-value of 0.83. Therefore, we cannot reject the hypothesis that our model for *SPREAD* is well specified.

In the equation that explains *RATING*, the estimate (*t*-stat.) for the instrumented *SPREAD* is −0.334 (−4.94). Therefore, corporate bond yield spreads affect debt rating. However, the estimate (*t*-stat.) for the instrumented *PCT_TB30Y* is −0.015 (−1.18). This suggests that understated pension liabilities do not affect debt rating. The overidentifying restrictions test statistic is 3.30 with a *p*-value of 0.35. We cannot reject the hypothesis that our model for *RATING* is well specified.

In the equation that explains *PCT_TB30Y*, the estimate (*t*-stat.) for the instrumented *SPREAD* is −0.005 (−0.14). The estimate (*t*-stat.) for the instrumented *RATING* is 0.560 (2.00). The implication is that corporate bond yield spreads do not affect understated pension liabilities, but S&P debt ratings do affect understated pension liabilities.

From other measures of understated pension liabilities in Panels A and B of Table 7, we reach essentially the same conclusions. Basically, firms with lower S&P ratings tend to hide more of their pension liabilities by choosing a higher pension discount rate. Debt market investors understand managers' attempts to hide and charge more in the form of higher yields when firms issue debts. There is a small fraction of firms that overstate their pension liabilities relative to stipulated interest rate benchmarks. In this case, debt market investors adjust by lowering the yields they charge when firms issue debts. The results in Table 7 are legitimate in the sense that all model specifications pass the overidentifying restriction tests.

5. Conclusions

Prior to the enactment of the (ERISA in 1974, pension liabilities were not liabilities of the firm. At plan termination, beneficiaries or employees could only claim on the assets of the pension fund, with no recourse on the general corporate assets. After the passage of ERISA, pension assets and liabilities are, in general, treated as corporate assets and liabilities. Pension liabilities hold the same priority as federal tax liens; that is, senior to debentures, bank loans and claims by other corporate creditors. The claims of the debentures' holders are effectively subordinated to those of the pension beneficiaries. If the capital market is efficient, one would expect information related to pension items to be reflected in bond yields. Earlier studies document that funded status and mandatory contributions affect corporate bond yield spreads. In this paper, we analyze the impact of understated pension liabilities on corporate bond yield spreads.

Firms have a lot of latitude in choosing pension discount rates. They often choose pension discount rates that are above the 30-year Treasury bond yields and long-term AAA-grade

Table 7. Two-stage least square (2SLS) regression of corporate bond yield spread, S&P debt rating and understated pension liabilities

Panel A: Understated PBOs

Dependent variable	EQ1 *SPREAD*	EQ2 *RATING*	EQ3 *PCT_ TB30Y*	EQ1 *SPREAD*	EQ2 *RATING*	EQ3 *PCT_ AAA20Y*	EQ1 *SPREAD*	EQ2 *RATING*	EQ3 *PCT_ AAA25Y*	EQ1 *SPREAD*	EQ2 *RATING*	EQ3 *PCT_ AAATM*
SPREAD (Inst.)		−0.334 (−4.94)**	−0.005 (−0.14)		−0.335 (−4.94)**	−0.002 (−0.05)		−0.335 (−4.93)**	−0.006 (−0.19)		−0.335 (−4.94)**	0.005 (0.14)
RATING (Inst.)	−0.225 (−3.37)**		0.560 (2.00)**	−0.227 (−3.39)**		0.487 (1.98)**	−0.227 (−3.40)**		0.543 (2.16)**	−0.231 (−3.45)**		0.550 (2.06)**
UPBO (Inst.)	−0.047 (−4.15)**	−0.015 (−1.18)		−0.052 (−4.12)**	−0.017 (−1.19)		−0.051 (−4.10)**	−0.017 (−1.19)		−0.050 (−3.92)**	−0.017 (−1.21)	
MAT	0.158 (12.01)**	0.068 (4.67)**		0.158 (12.02)**	0.068 (4.67)**		0.158 (12.01)**	0.068 (4.67)**		0.159 (12.04)**	0.068 (4.67)**	
OAMT	−0.196 (−2.51)**	−0.331 (−4.46)**		−0.195 (−2.48)**	−0.331 (−4.46)**		−0.195 (−2.49)**	−0.331 (−4.46)**		−0.193 (−2.46)**	−0.330 (−4.46)**	
COUP	1.712 (8.84)**			1.709 (8.83)**			1.704 (8.80)**			1.695 (8.74)**		
SENIOR	0.007 (0.05)	0.423 (2.63)**		0.006 (0.04)	0.422 (2.62)**		0.005 (0.03)	0.421 (2.62)**		0.001 (0.01)	0.419 (2.61)**	
FUNGIBLE	−0.280 (−3.74)**			−0.280 (−3.74)**			−0.282 (−3.75)**			−0.286 (−3.79)**		
TENDER	0.254 (2.48)**			0.252 (2.47)**			0.255 (2.50)**			0.250 (2.44)**		
INV_GRD	0.183 (0.69)	3.041 (23.65)**	−1.709 (−1.64)	0.189 (0.71)	3.040 (23.65)**	−1.486 (−1.63)	0.190 (0.71)	3.040 (23.64)**	−1.695 (−1.80)*	0.213 (0.80)	3.044 (23.71)**	−1.542 (−1.55)
ME_INF	0.154 (2.35)**	0.601 (13.92)**	−0.284 (−1.59)	0.156 (2.37)**	0.601 (13.92)**	−0.230 (−1.47)	0.155 (2.35)**	0.601 (13.91)**	−0.282 (−1.76)*	0.154 (2.34)**	0.600 (13.89)**	−0.314 (−1.85)*
COVERAGE		0.023 (4.65)**	0.010 (1.04)		0.023 (4.65)**	0.008 (0.99)		0.023 (4.65)**	0.008 (0.93)		0.023 (4.66)**	0.016 (1.64)
MARGIN		1.461 (3.31)**	1.882 (2.00)**		1.458 (3.31)**	1.579 (1.92)*		1.457 (3.31)**	1.548 (1.83)*		1.452 (3.30)**	1.441 (1.46)
LLEV		−3.587 (−10.94)**	3.994 (2.81)**		−3.586 (−10.93)**	3.564 (2.82)**		−3.586 (−10.94)**	3.792 (2.97)**		−3.575 (−10.87)**	4.398 (3.23)**
PPE		0.685 (2.88)**	−0.452 (−0.77)		0.683 (2.88)**	−0.441 (−0.84)		0.682 (2.87)**	−0.544 (−1.03)		0.685 (2.88)**	−0.276 (−0.45)
ASTD	0.742 (4.80)**	−0.538 (−3.17)**	0.585 (1.19)	0.742 (4.80)**	−0.537 (−3.17)**	0.530 (1.21)	0.744 (4.81)**	−0.536 (−3.16)**	0.631 (1.41)	0.751 (4.86)**	−0.534 (−3.14)**	0.806 (1.69)*
TB1Y	−0.504 (−6.91)**	−0.215 (−3.15)**	1.130 (7.09)**	−0.508 (−6.99)**	−0.216 (−3.17)**	0.935 (6.82)**	−0.503 (−6.89)**	−0.215 (−3.15)**	1.038 (7.26)**	−0.505 (−6.90)**	−0.215 (−3.14)**	1.010 (6.64)**
TERM	−0.645 (−7.82)**	−0.390 (−4.61)**	1.468 (6.90)**	−0.652 (−7.92)**	−0.392 (−4.63)**	1.197 (6.66)**	−0.645 (−7.81)**	−0.391 (−4.61)**	1.342 (6.94)**	−0.648 (−7.82)**	−0.391 (−4.60)**	1.294 (6.22)**
ED1TB3	−0.134 (−2.49)**	−0.018 (−0.27)	−0.604 (−2.87)**	−0.132 (−2.45)**	−0.017 (−0.26)	−0.506 (−2.79)**	−0.134 (−2.49)**	−0.018 (−0.27)	−0.556 (−2.81)**	−0.130 (−2.40)**	−0.017 (−0.25)	−0.502 (−2.67)**
FS			0.074 (2.53)**			0.075 (2.91)**			0.086 (3.29)**			0.126 (4.36)**
MC			2.922 (8.97)**			2.527 (8.64)**			2.452 (8.27)**			2.017 (6.01)**
OIR test statistic (*p*-value)	1.51 (0.83)	3.30 (0.35)	0.36 (0.99)	1.71 (0.79)	3.28 (0.35)	0.85 (0.93)	1.91 (0.75)	3.29 (0.35)	0.94 (0.92)	2.60 (0.63)	3.23 (0.36)	1.51 (0.83)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.633	0.796	0.523	0.633	0.796	0.529	0.633	0.796	0.516	0.632	0.796	0.498
Observations	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213

Panel B: Understated ABOs

Dependent variable	EQ1 *SPREAD*	EQ2 *RATING*	EQ3 *APCT_ TB30Y*	EQ1 *SPREAD*	EQ2 *RATING*	EQ3 *APCT_ AAA20Y*	EQ1 *SPREAD*	EQ2 *RATING*	EQ3 *APCT_ AAA25Y*	EQ1 *SPREAD*	EQ2 *RATING*	EQ3 *APCT_ AAATM*
SPREAD (Inst.)		−0.334 (−4.93)**	0.001 (0.01)		−0.335 (−4.93)**	0.004 (0.13)		−0.335 (−4.93)**	0.001 (0.01)		−0.335 (−4.94)**	0.011 (0.36)
RATING (Inst.)	−0.224 (−3.35)**		0.485 (2.00)**	−0.226 (−3.38)**		0.415 (1.95)*	−0.227 (−3.39)**		0.477 (2.12)**	−0.231 (−3.44)**		0.467 (1.97)**
UABO (Inst.)	−0.052 (−4.14)**	−0.016 (−1.17)		−0.058 (−4.11)**	−0.019 (−1.18)		−0.056 (−4.07)**	−0.018 (−1.19)		−0.054 (−3.90)**	−0.018 (−1.20)	

(*continued*)

Table 7.

Panel B: Understated ABOs

Dependent variable	EQ1 SPREAD	EQ2 RATING	EQ3 APCT_ TB30Y	EQ1 SPREAD	EQ2 RATING	EQ3 APCT_ AAA20Y	EQ1 SPREAD	EQ2 RATING	EQ3 APCT_ AAA25Y	EQ1 SPREAD	EQ2 RATING	EQ3 APCT_ AAATM
MAT	0.158 (12.01)**	0.068 (4.67)**		0.159 (12.02)**	0.068 (4.67)**		0.159 (12.01)**	0.068 (4.67)**		0.159 (12.04)**	0.068 (4.67)**	
OAMT	−0.197 (−2.52)**	−0.332 (−4.47)**		−0.195 (−2.49)**	−0.331 (−4.46)**		−0.196 (−2.50)**	−0.331 (−4.47)**		−0.194 (−2.47)**	−0.330 (−4.46)**	
COUP	1.711 (8.84)**			1.707 (8.82)**			1.703 (8.79)**			1.695 (8.74)**		
SENIOR	−0.003 (−0.02)	0.420 (2.61)**		−0.005 (−0.03)	0.418 (2.60)**		−0.002 (−0.02)	0.419 (2.61)**		−0.009 (−0.06)	0.416 (2.59)**	
FUNGIBLE	−0.281 (−3.76)**			−0.280 (−3.75)**			−0.282 (−3.77)**			−0.286 (−3.80)**		
TENDER	0.255 (2.50)**			0.254 (2.49)**			0.256 (2.52)**			0.252 (2.46)**		
INV_GRD	0.180 (0.68)	3.041 (23.64)**	−1.495 (−1.63)	0.186 (0.70)	3.040 (23.63)**	−1.281 (−1.59)	0.190 (0.71)	3.040 (23.64)**	−1.494 (−1.75)*	0.211 (0.79)	3.044 (23.70)**	−1.304 (−1.44)
ME_INF	0.153 (2.32)**	0.601 (13.91)**	−0.282 (−1.83)*	0.154 (2.34)**	0.601 (13.91)**	−0.222 (−1.64)	0.153 (2.33)**	0.600 (13.91)**	−0.276 (−1.93)*	0.153 (2.32)**	0.600 (13.88)**	−0.292 (−1.93)*
COVERAGE		0.023 (4.66)**	0.014 (1.60)		0.023 (4.65)**	0.012 (1.54)		0.023 (4.66)**	0.011 (1.40)		0.023 (4.67)**	0.018 (2.08)**
MARGIN		1.457 (3.31)**	1.616 (1.92)*		1.455 (3.31)**	1.384 (1.88)*		1.453 (3.30)**	1.314 (1.70)*		1.449 (3.29)**	1.261 (1.41)
LLEV		−3.586 (−10.93)**	3.569 (2.95)**		−3.585 (−10.93)**	3.164 (2.95)**		−3.585 (−10.93)**	3.466 (3.09)**		−3.575 (−10.87)**	3.892 (3.29)**
PPE		0.683 (2.87)**	−0.501 (−0.98)		0.681 (2.86)**	−0.487 (−1.06)		0.680 (2.86)**	−0.563 (−1.18)		0.683 (2.87)**	−0.336 (−0.61)
ASTD	0.741 (4.80)**	−0.539 (−3.18)**	0.451 (1.06)	0.741 (4.79)**	−0.538 (−3.17)**	0.408 (1.09)	0.741 (4.79)**	−0.538 (−3.17)**	0.487 (1.22)	0.748 (4.83)**	−0.535 (−3.15)**	0.621 (1.48)
TB1Y	−0.503 (−6.90)**	−0.215 (−3.14)**	1.036 (7.62)**	−0.507 (−6.98)**	−0.216 (−3.17)**	0.850 (7.15)**	−0.503 (−6.90)**	−0.215 (−3.14)**	0.950 (7.57)**	−0.505 (−6.91)**	−0.215 (−3.14)**	0.921 (6.87)**
TERM	−0.644 (−7.80)**	−0.390 (−4.60)**	1.341 (7.22)**	−0.651 (−7.90)**	−0.392 (−4.62)**	1.089 (6.91)**	−0.645 (−7.81)**	−0.390 (−4.60)**	1.227 (7.10)**	−0.648 (−7.82)**	−0.391 (−4.60)**	1.182 (6.38)**
ED1TB3	−0.136 (−2.51)**	−0.018 (−0.28)	−0.565 (−3.05)**	−0.133 (−2.47)**	−0.018 (−0.27)	−0.471 (−2.96)**	−0.135 (−2.50)**	−0.018 (−0.27)	−0.519 (−2.93)**	−0.132 (−2.43)**	−0.017 (−0.26)	−0.481 (−2.86)**
FS			0.067 (2.63)**			0.068 (3.02)**			0.082 (3.47)**			0.116 (4.48)**
MC			2.626 (9.20)**			2.262 (8.80)**			2.208 (8.22)**			1.832 (6.07)**
OIR test statistic (*p*-value)	1.56 (0.82)	3.32 (0.34)	0.88 (0.93)	1.77 (0.78)	3.29 (0.35)	1.63 (0.80)	2.02 (0.73)	3.29 (0.35)	1.50 (0.83)	2.69 (0.61)	3.24 (0.36)	2.26 (0.69)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.633	0.796	0.554	0.633	0.796	0.555	0.633	0.796	0.540	0.632	0.796	0.523
Observations	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213	2,213

Note(s): The sample covers 2,213 firm-year observations from January 1989 to December 2013. The table reports the 2SLS regressions for the determinants of corporate bond yield spreads (*SPREAD*), S&P debt rating (*RATING*) and understated pension liabilities (*USPL*s). Understated pension liabilities include *UPBO*s (*PCT_TB30Y*, *PCT_AAA20Y*, *PCT_AAA25Y*, *PCT_AAATM*) and *UABO*s (*APCT_TB30Y*, *APCT_AAA20Y*, *APCT_AAA25Y*, *APCT_AAATM*). The regressions include exogenous variables that belong to the following categories: issue characteristics, firm characteristics, macroeconomic variables and pension variables. Issue characteristics include maturity (*MAT*), offered amount (*OAMT*), coupon rate (*COUP*), a dummy variable for debt security level that is equal to seniority (*SENIOR*), a dummy variable for debt issue that is fungible (*FUNGIBLE*), a dummy variable for debt issued under tender or exchange offer (*TENDER*) and a dummy variable for investment grade bond (*INV_GRD*). Firm characteristics include inflation-adjusted market value in constant 2013 US billion $ (*ME_INF*), interest coverage (*COVERAGE*), operating margin (*MARGIN*), long-term debt leverage (*LLEV*), ratio of fixed assets to total assets (*PPE*) and time-trend–adjusted residual standard deviations (*ASTD*) within each fiscal year. Macroeconomic variables include one-year Treasury note yield (*TB1Y*), term premium calculated as the difference between 10-year and one-year Treasury note yields (*TERM*) and Eurodollar premium calculated as the difference between the one-month Eurodollar rate and three-month Treasury bill rate (*ED1TB3*). Pension variables include funded status (*FS*) and mandatory contributions (*MC*). The definitions of the variables are provided in Appendix 1. Corporate bond yield spreads are the difference between corporate debt yield at issue and the corresponding AAA-grade corporate debt yield of the closest maturity. S&P debt ratings are numbered from 22 for AAA to 1 for D. Overidentifying restrictions test statistics (OIR) (*p*-values) are also reported. ** indicates significance at the 5% level; * indicates significance at the 10% level corporate bond yields. For example, the average understated pension liabilities relative to 30-year Treasury bond yields amount to $394.3 million and $359.3 million for projected and ABOs, or 3.5 and 3.1% of beginning of the fiscal year end market value. Compared to funded status of −3.75% and mandatory contributions of −0.56% of the beginning of the fiscal year market value, the understated pension liabilities are economically large. The average amount of money raised in our sample of 2,213 debt offerings is $413 million. Therefore, by changing pension discount rates, firms can easily write off pension obligations as large as the proceeds from a typical debt issue during the 1989–2013 period.

The question is whether debt market investors see through managers' attempts to hide their pension obligations. We establish a robust relation between understated pension liabilities and corporate bond yield spreads after controlling for factors that have been previously identified as having a significant impact on firms' cost of borrowing. Our results support the idea that bond market investors are not being misled by the use of high pension liability discount rates by some companies to lower their reported pension obligations. For a small fraction of debt issuers, the reported pension liabilities are larger than the pension liabilities valued at the stipulated interest rate benchmarks. For these issuers with overstated pension liabilities, bond investors adjust their borrowing costs downwards.

S&P Rating Services recognizes the issue that there is considerably more variability in discount rate assumptions among companies than in workforce demographics or the interest rate environment in which firms operate (Standard and Poor's, 2006). S&P also indicates that it would be desirable to normalize different discount rate assumptions but acknowledges that it is difficult to do so. In practice, S&P Rating Services conducts periodic surveys to see whether firms' assumed discount rates conform to the normal standard. Our paper makes an initial attempt to quantify the size of understated pension liabilities and their impact on corporate bond yield spreads. Our approach can be extended to study firms' costs of equity capital, the pricing of seasoned equity offerings and the pricing of merger and acquisition transaction deals, among other questions.

Notes

1. The Job Creation and Worker Assistance Act of 2002 temporarily increases the upper bound of the range to 120% for plan years 2002 and 2003.

2. The Pension Funding Equity Act of 2004 replaces the interest rates on 30-year Treasury bonds with a composite rate on long-term investment grade corporate bonds. The change is in effect only for plan years 2004 and 2005 after which the rates on 30-year Treasury bonds again apply.

3. The empirical evidence suggests that, in fact, our simple estimates of understated pension liabilities are very conservative. The average difference between pension discount rates and 30-year Treasury bond yields is 1.22% in our sample of 2,213 firm-year observations. Lucas and Zeldes (2006) suggest a difference of 2.05% between the theoretically correct time-varying discount rate of 5.70% and the assumed discount rate of 7.75% for Alcoa in 2001. The pension liabilities will be much larger under the Lucas and Zeldes (2006) model than under our simple approach.

4. We construct four variables to examine the role of block and institutional investors: top-5 largest institutional owners, top-10 largest institutional owners, block ownership and total ownership by institutional investors. We also examine four corporate governance measures: percentage of board members that are independent, percentage of bond members that hold stocks in the firm, the Gompers *et al.*'s (2003) index and the Bebchuk *et al.*'s (2009) index. None of the above variables are consistently significant in various model specifications. One main reason for this lack of significance is that adding these variables significantly reduces the number of firm-year observations to somewhere between 521 and 1,853.

5. We construct two categories of transparency measures related to corporate bond yield spreads. The first is based on accounting accruals (Dechow *et al.*, 1995; Francis *et al.*, 2004, 2005; Hutton *et al.*, 2009; Lang and Maffett, 2011; Lang *et al.*, 2012). The second is based on stock market reaction to

earnings information (Ashbaugh-Skaife *et al.*, 2006; Barth *et al.*, 2013). Nonetheless, these transparency measures are not significant during our sample period. Again, the problem is most likely due to our relatively small sample size, as we only examine yields on the first debt issued during the fiscal year when measuring marginal cost of debt.

6. We construct a dummy variable to capture those bonds issued after this date. The dummy variable also turns out to be insignificant in explaining yield spreads.

7. During our sample period from January 1989 to December 2013, the average number of bonds that constitute 15, 20, 25 and 30-year AAA-grade corporate bond yields are 59, 44, 46 and 15. The average number of bonds that constitute 15, 20, 25 and 30-year AA-grade corporate bond yields are 46, 40, 65 and 29. The number of shorter maturity AAA-grade and AA-grade bonds is much larger.

8. See FISD dictionary, page 44–45 (Mergent Inc, 2012).

9. The firm-year observations and number of firms with pension information are consistent with those reported in Rauh (2006) and Picconi (2006). Rauh's (2006) sample consists of 8,050 firm-year observations from 1990 to 1998. Picconi's (2006) sample consists of 15,553 firm-year observations from 1988 to 2001.

10. The majority or 2,015 of 2,213 debts carried S&P ratings issued in the same months as the offering months. A total of 149 debts carried S&P ratings issued within 3 months of the offering months.

11. Among these 2,213 observations, ABOs are missing for 544. This happens mainly during the 1998–2003 period when SFAS 132 no longer requires firms to disclose their ABOs when plan assets exceed the 1998 ABO. This is reversed in SFAS 132 (R), effective in 2003, when FASB again requires the disclosure of ABOs. Following Hann *et al.* (2007), for these 544 observations, we replace the number of years to retirement by the individual firm's median value of number of years to retirement and impute the ABOs based on the relation between ABOs and PBOs.

12. Among the 2,213 debt issues, 2,007 are senior, 1,032 are fungible, 474 have at least one tender or exchange offer, 1,744 are redeemable, 19 are puttable, 178 have credit enhancement features, 1,768 have various covenants and 465 are issued under Rule 144 A. A total of 1,684 bonds are investment grade with S&P individual debt ratings BBB- or above. None of the 2,213 bonds are private placed, convertible, exchangeable, defaulted, denominated in foreign currency, Canadian, asset-backed, Yankee or unit deal. Following Elton *et al.* (2001), we create dummies to capture these bond features and find only four dummy variables representing senior, fungible, tender or exchange offered, and investment grade bonds affect either bond yield spreads or issue-specific ratings. We keep these four dummy variables in subsequent analysis.

13. We also consider beta within the corresponding fiscal year, but the results are not significant.

14. Rauh (2006) provides a detailed description of the formula for mandatory contributions.

15. Our valuation results are essentially the same if the funding shortfall is amortized over a seven-year period.

16. The quartile groups are based on a larger sample of 22,038 firm-year observations. This sample is constructed for 1,567 firms that we can measure understated pension liabilities during the January 1989–December 2013 period. The quartile group breakpoints based on the ratio of service cost to interest cost are 0.33, 0.51 and 0.84, respectively. The quartile group breakpoints based on the estimated number of years to retirement $\widehat{N}$ are 1.41, 2.68 and 4.32, respectively.

17. The sample of 2,213 firm-year observations involves 593 firms and requires the availability of both debt issue and pension data. To check the robustness of the above results, we construct a second sample which only requires the availability of pension discount rates in two consecutive fiscal years for the same 593 firms during the same period from 1989 to 2013. Now the firm-year observations increase to 9,654. The empirical results from this second sample in Table 2 essentially mirror those from the first sample. For example, the average differences between pension discount rate and benchmark interest rate are 1.08%, 0.88%, 0.90% and 0.80%, respectively, relative to the 30-year Treasury bond, 20-year, 25-year and term-structure AAA-grade corporate bond yields.

18. Lucas and Zeldes (2006) develop a model for valuing and hedging pension liabilities. In their model, the discount rate for PBOs should be time-varying because the value of PBOs depends on expected future salary. The empirical evidence indicates that aggregate wage growth rate is positively correlated with stock market returns. Therefore, the pension discount rate should adjust for this risk. For a large company Alcoa in 2001, the Lucas and Zeldes (2006) model implies a pension discount rate of 5.70%. The actual pension discount rate used by Alcoa in 2001 was 7.75%, leading to a difference of 2.05% between the model discount rate and assumed discount rate. We use this 2.05% difference as a guideline. For our sample of 2,213 firm-year observations, the average difference, relative to the 30-year Treasury bond yield, is 1.22% as reported in Panel A1 of Table 2. The difference at the 90% cutoff point of our 2,213 sample is 2.06%. In other words, for most (90%) of our firm-year observations, the difference between assumed pension discount rates and 30-year Treasury bond yields is less than the guideline difference of 2.05% from the Lucas and Zeldes (2006) model. In this regard, our estimates of pension liabilities using 30-year Treasury bond and AAA-grade corporate bond yields are conservative. As a result, our estimates of understated pension liabilities are also conservative.

19. Each of the 12 calendar dummy variables correspond to two calendar years from 1990 to 2013. The first calendar dummy corresponds to year 1989.Thirty industry classifications are based on Fama and French (1997). Financial industry is excluded.

20. The total observations in our sample is 2,213. Among them, less than 10% are negative in general, while the majority are positive. The mean value of overstated pension liabilities is between 1.26% and 1.72% relative to alternative interest rate benchmarks. The mean value of understated pension liabilities is between −3.80% and −3.02% relative to alternative interest rate benchmarks.

21. We obtain TRACE corporate bond transaction data and construct three measures during the first 66 trading days, or roughly 3 months after the bond is issued. The three measures are the percentage of zero daily returns, the Amihud (2002) measure and the Corwin and Shultz (2012) measure. Since TRACE transaction data are only available after July 2, 2002, our original sample of 2,213 firm-year observations is reduced to 1,033 after we require that the bonds are issued after July 2002 and that a minimum of 10 days transaction data are available to measure liquidity on TRACE. The Amihud (2002) and Corwin and Shultz (2012) measures are not significant in explaining yield spreads. The percentage of daily returns is significant in explaining yield spreads.

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Appendix 1
Construction of pension, market and accounting variables

This appendix provides the definitions, references and details of the COMPUSTAT accounting items used to construct the pension, accounting and market variables.

Variable name and references	COMPUSTAT items
Pension variables	
Plan assets (*PA*)	*PA* = pension plan assets + underfunded pension plan assets = *PPLAO* + *PPLAU*
Plan benefit obligations (*PBO*)	*PBO* = projected benefit obligation + underfunded projected benefit obligation = *PBPRO* + *PBPRU*
Funded status (*FS*)	*FS* = plan assets – plan benefit obligation = *PA* – *PBO*
Accumulated benefit obligations (*ABO*)	*ABO* = accumulated benefit obligation + underfunded accumulated benefit obligation = *PBACO* + *PBACU*
Mandatory contributions (*MC*)	*MC* = –[service cost + minimum pension liabilities/30] = –[*SC* + *MPL*/30] if *ABO* > *PA*; *MC* = 0 if otherwise *MPL* = minimum pension liabilities = *ABO* – *PA* if *ABO* > *PA*; *MPL* = 0 if otherwise
Understated pension liabilities (USPLs)	
Understated PBOs (*UPBOs*) *PCT_TB30Y*, *PCT_AAA20Y*, *PCT_AAA25Y*, *PCT_AAATM*, *PCT_AA20Y*, *PCT_AA25Y*, *PCT_AATM*	$PCT\_TB30Y = (PBO - PBO^{Benchmark})/ME(-1)$ $PBO^{Benchmark}$ = PBO evaluated at 30-year Treasury bond yield (r^{TB30Y}) Others are defined in a similar way relative to 20-year, 25-year and term structure AAA-grade corporate bond yields (r^{AAA20Y}, r^{AAA25Y}, and r^{AAATM}) and 20-year, 25-year and term structure AA-grade corporate bond yields (r^{AA20Y}, r^{AA25Y} and r^{AATM})
Understated ABOs (*UABOs*) *APCT_TB30Y*, *APCT_AAA20Y*, *APCT_AAA25Y*, *APCT_AAATM*, *APCT_AA20Y*, *APCT_AA25Y*, *APCT_AATM*	$APCT\_TB30Y = (ABO - ABO^{Benchmark})/ME(-1)$ $ABO^{Benchmark}$ = *ABO* evaluated at 30-year Treasury bond yield (r^{TB30Y}) Others are defined in a similar way relative to 20-year, 25-year and term structure AAA-grade corporate bond yields (r^{AAA20Y}, r^{AAA25Y} and r^{AAATM}) and 20-year, 25-year and term structure AA-grade corporate bond yields (r^{AA20Y}, r^{AA25Y} and r^{AATM})
Issue characteristics	
Corporate bond yield at issue (*YIELD*)	FISD item Offering_yield
Corporate bond yield spread (*SPREAD*)	Offering_yield – AAA-grade corporate bond yield of the closest maturity
Maturity (*MAT*)	Maturity of the debt
S&P debt rating (*RATING*)	S&P debt rating, 22 = AAA, 21 = AA+, 20 = AA, 19 = AA–, 18 = *A*+, 17 = A, 16 = A–, 15 = BBB+, 14 = BBB, 13 = BBB–, 12 = BB+, 11 = BB, 10 = BB–, 9 = B+, 8 = B, 7 = B–, 6 = CCC+, 5 = CCC, 4 = CCC-, 3 = CC, 2 = C, D = 1
Offered amount (*OAMT*)	FISD item Offering_amt
Coupon (*COUP*)	FISD item coupon
Dummy for security level equals seniority (*SENIOR*)	FISD item Security_level = SEN
Dummy for debts that are fungible (*FUNGIBLE*)	FISD item fungible = YES
Dummy for debts issued under tender or exchange offer (*TENDER*)	FISD item Tender_exch_offer = YES

(*continued*)

Variable name and references	COMPUSTAT items
Dummy for investment grade bonds (*INV_GRD*)	Bonds with S&P issue-specific rating; *RATING* = BBB- and above
Firm characteristics	
Market size (*ME_INF*)	*ME* = market equity at fiscal year end of year *t* = fiscal year end stock price × common shares outstanding = fiscal year end stock price × *CSHO* *ME* is adjusted for inflation and is in December 2013 constant dollars
Interest coverage (*COVERAGE*)	*COVERAGE* = (operating income after depreciation + interest expense)/interest expense = *(OIADP + INT)/INT*
Operating margin (*MARGIN*)	MARGIN = operating income before depreciation/sales = *OIBDP/SALE*
Long-term debt leverage (*LLEV*)	*LLEV* = long-term debt/total assets = *DLTT/AT*
The ratio of fixed assets to total assets (*PPE*)	*PPE* = net property, plant and equipment/total assets = *PPENT/AT*
Adjusted residual standard deviations (*ASTD*)	The residual is from the following regression (Dimson, 1979) $r_{i,t} = \beta_0 + \beta_1 r_{m,t} + \beta_2 r_{m,t+1} + \beta_3 r_{m,t-1} + \varepsilon_{i,t}$, Where $r_{i,t}$ is daily individual stock returns within the fiscal year and $r_{m,\,t}$ is the corresponding daily return on CRSP value-weighted market portfolio The standard deviations of the residuals are scaled by cross-sectional means for each year
Macroeconomic variables	
One year T-note yield (*TB1Y*)	One-year Treasury note yield
Term premium (*TERM*)	Difference between 10-year and one-year Treasury note yields
Eurodollar premium (*ED1TB3*)	Difference between one-month Eurodollar rate and three-month Treasury bill rate

Appendix 2

Construction of Understated Pension Liabilities

In order to estimate the value of PBOs and ABOs relative to alternative interest rate benchmarks, we need to find the estimates for pension benefit formula parameters such as number of years to retirement, percentage of current salary to be received after retirement and current wages. These items are not available from COMPUSTAT. However, Hann *et al.* (2007) developed methods to obtain these parameters at the aggregate firm level. Then, we replaced the assumed pension discount rate by alternative interest rate benchmarks to obtain the new PBO or ABO values. Notice that *PBO* is defined as:

$$PBO = \frac{A_L \times KW \times (1+g)^N}{(1+r^{DISCOUNT})^N}, \tag{A1}$$

where $A(r^{DISCOUNT}, L) = r^{-1}(1-(1+r^{DISCOUNT})^{-L})$ is the annuity factor of an L period annuity at a pension discount rate of $r^{DISCOUNT}$. L is the life expectancy of workers; K is the proportion of employees' wages that are payable given current service performed and vesting; and W, g and N denote current wages, compensation growth rate and number of years to retirement, respectively. $KW(1+g)^N$ measures the expected pension benefit annuity to be paid over life expectancy L years after retirement. Following Hann *et al.* (2007), we assume life expectancy L to be 15. Then, based on the relation between *PBO* and *ABO*, we estimate the number of years to retirement N as follows:

$$PBO = ABO(1+g)^N. \tag{A2}$$

Then, we calculate N as:

$$\widehat{N} = \log(PBO/ABO)/\log(1+g). \tag{A3}$$

Note that ABO disclosure was not required under SFAS 132, effective between 1998 and 2003. During this period, the missing ABOs total 544 out of 2,213. To circumvent this problem, for each firm, we replace the missing $\widehat{N}$ by the corresponding median value from the non-missing observations. After the replacement, the median value of the estimated $\widehat{N}$ is 2.17 years and the mean value is 2.70 years, similar to those reported in Hann *et al.* (2007). The 5 and 95% figures of $\widehat{N}$ in our sample are 0.30 and 6.52 years, respectively. $\widehat{N}$ provides an estimate for the average expected remaining years of service within the firm. A relatively small $\widehat{N}$ reflects a high proportion of retirees in the pension plan. Now, we can find the pension benefit formula parameter KW as:

$$K\widehat{W} = \frac{PBO \times \left(1 + r^{DISCOUNT}\right)^{\widehat{N}}}{A(r^{DISCOUNT}, \widehat{L}) \times (1+\widehat{g})^{\widehat{N}}}. \tag{A4}$$

As a result, PBO discounted at the 30-year Treasury bond yield can be calculated as:

$$PBO^{TB30Y} = \frac{A(r^{TB30Y}, \widehat{L}) \times K\widehat{W} \times (1+\widehat{g})^{\widehat{N}}}{(1+r^{TB30Y})^{\widehat{N}}}. \tag{A5}$$

The understated PBO is the difference between the reported PBO and PBO^{TB30Y} divided by the beginning of the fiscal year market value $ME(-1)$:

$$PCT\_TB30Y = \frac{PBO - PBO^{TB30Y}}{ME(-1)}. \tag{A6}$$

Similarly, ABO discounted at the 30-year Treasury bond yield can be computed as:

$$ABO^{TB30Y} = \frac{A\left(r^{TB30Y}, \widehat{L}\right) \times K\widehat{W}}{(1+r^{TB30Y})^{\widehat{N}}}. \tag{A7}$$

The understated ABO is the difference between the reported ABO and ABO^{TB30Y} divided by the fiscal year end market value $ME(-1)$:

$$APCT\_TB30Y = \frac{ABO - ABO^{TB30Y}}{ME(-1)}. \tag{A8}$$

Understated PBOs and ABOs relative to AAA-grade and AA-grade corporate bond yields are calculated in an analogous way.

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