CAPITAL STRUCTURE PRIORITY EFFECTS IN DURATIONS, STOCK-BOND COMOVEMENTS AND FACTOR-PRICING MODELS

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Abstract

We show theoretically and empirically that the durations of corporate securities are monotonically related to their capital structure priority, with equity often having negative duration. The magnitude of this effect increases with firm leverage. We use these insights to challenge existing results on stock-bond comovements and factor pricing. For example, though overlooked, higher leverage and lower priority reduce the correlation between corporate security and government bond returns and these variables explain time-series and cross-sectional variation in correlations; traditional market model regressions significantly understate corporate bond betas; regressions on standard term and default factors dramatically overstate interest rate and default risk.

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Why do stock and bond markets move in opposite directions? In contrast to traditional explanations, which relate comovements in bond and equity markets to business cycles, this paper appeals to structural models of corporate security valuation in the spirit of Merton (1974). One key insight is that, under the assumption that the value of a firm's assets is independent of interest rates, lower priority securities in the capital structure, such as subordinated debt and equity, have low or even negative durations, where duration is defined in the classic sense as the negative of a measure of the interest rate sensitivity of these returns.[1] Intuitively, the lower priority securities are effectively short higher priority, positive duration, fixed rate debt. Consequently, it is critical to account for the priority structure of firms' securities to understand the comovement of stock and bond markets.

While the models in this paper are not new, our theoretical results on the joint impact of priority and leverage on the durations of corporate securities are novel. Our predictions are derived from the comparative statics of a standard structural credit risk model a la Merton (1974) and Chance (1990), with stochastic interest rates as in Schaefer and Strebulaev (2008), among others. We test these predictions and confirm empirically that the durations of corporate securities depend on the leverage of the firm and the priority of these securities within the capital structure.

Specifically, we estimate the effect of priority on the relation between a security's return and interest rate changes and deliver three main findings at the firm level. First, within groups of firms with similar leverage ratios, simple estimates of the duration of corporate securities increase with priority. For example, for firms with the lowest but non-zero levels of leverage, our duration estimates, using five-year constant maturity Treasury (CMT) yield changes, are -1.7, 2.2, and 2.9 for equity, junior debt, and senior debt, respectively. Second, controlling for the duration of the assets of the firm by examining the differences in durations across securities with different priority within the same firm, we again confirm that lower priority securities have lower durations. For example, equity has a duration that is, on average, 1.5 lower than the duration of bonds of the same firm. Finally, we estimate a pooled regression model across all the corporate securities in our sample in which duration is modeled as a function of leverage and priority, and where we control for security-specific characteristics and the duration of asset returns. We find that the duration of

[1] We define this measure of interest rate sensitivity more formally, in the context of our theoretical framework, in Section II.A, and we discuss the estimation of its empirical counterpart in Section II.B.

a corporate security is negatively related to firm leverage and positively related to the priority of the security, as measured by one minus the fraction of the bonds in the firm's capital structure that are senior to the security in question. This priority effect is both statistically and economically significant. For example, the duration of a senior bond in the firm's capital structure is 10.9% higher than the duration of an otherwise equivalent junior bond.

Our firm-level results on the durations of corporate securities have implications for stock and bond indexes. We pursue two main questions. First, what does our firm-level analysis imply about time variation in the empirical relation between index returns and interest rate changes, with the correlation between the S&P 500 and government bonds being perhaps the prototypical example? A large literature studies this correlation, for example, Campbell and Ammer (1993), Fama and French (1993), Connolly, Stivers and Sun (2005), Baele, Bekaert, and Inghelbrecht (2010), Baker and Wurgler (2012), Baele, Bekaert, Inghelbrecht and Wei (2013), Campbell, Sunderam, and Viceira (2013), Bansal, Connolly and Stivers (2014), Goyenko and Sarkissian (2014), Campbell, Pflueger and Viceira (2015), and Chiang, Li and Yang (2015), among others. Yet not one of these papers points to leverage and priority at the firm level as important factors. However, theory predicts that the average leverage of the firms and the average priority of the securities in the index should play important roles in explaining the correlation between corporate bond or equity index returns and interest rate changes. We confirm this implication empirically and show that the effect is economically large. For example, a one-standard-deviation increase in leverage decreases the government bond-equity correlation by 0.2. We also examine the differential impact of leverage on the correlations between government bond returns and returns on portfolios of corporate bonds from the same firms but with different seniority. A one-standard-deviation increase in the average leverage of the firms in the portfolio leads to a 13% larger drop in the correlation for junior debt than for senior debt.

Second, what does our firm-level analysis imply about existing empirical studies of the factor structure of returns on stocks and bonds? We identify three strands of this literature that fail to account for important capital structure priority effects: (i) estimates of corporate bond betas, (ii) studies using term and default premium risk factors, and (iii) models of time-varying expected returns on stocks and bonds. Exploiting the structural relation between stocks and bonds implied by their relative priority, we provide new results and reinterpret existing empirical findings.

Specifically, corporate bonds have more systematic risk than existing results suggest. Moreover, there has been a significant misattribution of the risk of corporate securities, and the associated expected returns, to term and default risk components. For example, regressions on traditional term and default factors significantly overstate interest rate risk and default risk premiums.

The paper is organized as follows. Section I places this paper in the context of the existing literature. Section II lays out the implications of the Merton (1974) model for the durations of corporate securities. Section III describes the firm-level data, and Section IV tests the implications of Section II using these data. Sections V and VI explore the implications of these findings for the correlation between aggregate bond and stock returns and for factor pricing models, respectively, and then provide corroborating empirical evidence. Section VII concludes.

I. Previous Literature

The thesis of this paper is that capital structure priority and leverage matter for determining the relation between corporate security returns and interest rate changes. There has been a plethora of research in finance that investigates the comovement properties of stock and bond returns, primarily at the aggregate or market level but also at the security or portfolio level. However, none of this research highlights capital structure priority as a main source of variation.

Indeed, the fundamental relation between these asset returns has been difficult to pin down. At the aggregate level, part of the problem is that covariation between stocks and bonds can derive from shocks to real and nominal aggregate cash flows,[2] changing expected returns,[3] or, in light of the lack of success of some of these asset pricing models, aggregate behavioral phenomena.[4] In particular, a number of papers have tried to explain the periods in which equity and bond returns have been negatively correlated. From a theoretical point of view, while the engine underlying the consumption-based asset pricing paradigm links the values of all long-term securities through a

[2] See Fama and Schwert (1977), Barsky (1989), Campbell and Ammer (1993), Fama and French (1993), and Boudoukh, Richardson, and Whitelaw (1994), among others, for theoretical and empirical investigations of common factors driving both stock and bond returns.
[3] See, for example, Keim and Stambaugh (1986), Fama and French (1989), and Campbell and Cochrane (1999), among others, for both empirical and theoretical descriptions of joint stock and bond return predictability.
[4] See Shiller and Beltratti (1992), Connolly, Stivers, and Sun (2005), Baele, Bekaert, and Inghelbrecht (2010) and Baker and Wurgler (2012) for an analysis of non-fundamental determinants of stock and bond return covariation.

common pricing factor, the underlying models can be tweaked to generate different relations between stock and bond returns.[5]

At the security level, the primary focus of the literature has been on the ability of structural models of credit risk to match observed bond prices, and the evidence on this dimension has been mixed. The earliest paper in this area, Jones, Mason and Rosenfeld (1984), documents disappointing results. To a large extent, these findings have been confirmed in various ways by Collin-Dufresne, Goldstein, and Martin (2001), Eom, Helwege, and Huang (2004), Bharath and Shumway (2008), Huang and Huang (2012), and Huang, Shi and Zhou (2020), among others. These authors find that a number of implications of structural models of corporate liabilities are not borne out in the data, though others take exception to this conclusion, e.g., Ericsson, Jacobs, and Oviedo (2009).

However, Blume, Keim, and Patel (1991) and, more recently, Schaefer and Strebulaev (2008) have had success in documenting comovements between equity returns and corporate bond returns that are consistent with contingent claims pricing models. Interestingly however, Schaefer and Strebulaev (2008) note that these models are unable to match the empirical interest rate sensitivity of corporate debt, which is substantially lower than that implied by the models. This finding confirms earlier results in Fons (1990), Longstaff and Schwartz (1995), and Duffee (1998). Our paper helps resolve this puzzle by recognizing that junior debt can have low or even negative duration.

On the theory side, our paper derives the durations of corporate securities as functions of security priority and firm leverage in the setting of Merton (1974) and Chance (1990) and delivers results that are novel to the literature. Using more advanced models than Merton (1974), Ramaswamy and Sundaresan (1993), Longstaff and Schwartz (1995) and Acharya and Carpenter (2002) also derive new relations between corporate bond returns and interest rate changes. However, none of these papers models the impact of priority structure on the duration of corporate debt or investigates the relation between equity returns and interest rates. One of the results derived by Longstaff and Schwartz (1995) and Acharya and Carpenter (2002) is that interest rate sensitivity

[5] See Campbell (2000), Campbell, Sunderam and Viceira (2013) and Koijen, Lustig, and Van Nieuwerburgh (2012) for examples of such asset pricing models.

is lower for riskier bonds. However, the model of Longstaff and Schwartz (1995) fails to relate bond recovery value to firm value, and Acharya and Carpenter (2002) consider only a single level of debt priority. In contrast, we explain the relation between duration and bond risk in terms of capital structure priority.

On the empirical side, our paper is the first to relate the durations of corporate securities to both leverage and capital structure priority. Our findings are related to two papers in particular, Duffee (1998) and Schaefer and Strebulaev (2008), who document declining interest rate sensitivity as a function of credit ratings. To the extent that credit rating agencies use leverage and priority as inputs in the ratings process, their result mirrors ours, at least with respect to corporate bonds. However, even if ratings were a sufficient statistic for leverage and priority, our analysis reveals the true underlying fundamental relation. There is also considerable evidence that credit ratings do not capture all relevant information about credit risk and, in particular, are slow to adjust to news, with credit rating agencies preferring to maintain ratings "through the cycle" (e.g., Ederington, Yawitz, and Roberts (1987), Löffler (2004) and Hilscher and Wilson (2017)). We show that priority remains significant even when credit ratings are included in our regression analysis. Schaefer and Strebulaev (2008) investigate individual bond returns, while controlling for equity returns, and thus provide an analysis closest to ours. They document lower than expected durations of corporate bonds. Huang and Shi (2016) partially resolve this puzzle by using a multifactor interest rate model. In contrast, even in our single factor framework, we find that a better-specified model that incorporates leverage and priority also produces lower durations.

II. Theoretical Framework and Hypothesis Development

In this section, we first present our theoretical framework and provide intuition about the relation between corporate security returns and risk-free interest rates. The analysis follows Merton (1974) and Chance (1990), with the key assumption being that corporate liabilities take the form of zero-coupon, fixed-rate debt. We also allow for stochastic interest rates that can be correlated with the value of the firm's assets.[6] Then we derive our main regression specification and develop a number of testable hypotheses based on the implications of our theory.

[6] In the Appendix we examine extensions of this model to incorporate early default prior to maturity and find that the base case intuition and results are preserved.

A. Theoretical Framework

First, we assume that the nominal value of the firm's assets V have constant volatility σ. Specifically, under the risk-neutral measure,[7]

$$\frac{dV}{V} = r\,dt + \sigma dZ\ ,$$

where r is the instantaneous nominal risk-free rate and Z is a standard Brownian motion. There are no transactions costs, information asymmetries or taxes so that the Modigliani-Miller theorem obtains; there is continuous trading; and investors can borrow and lend at the same rate.

Next, as in Vasicek (1977), we assume that r follows a mean-reverting process under the risk-neutral measure:

$$dr = q(m - r)dt + v\,dW\ ,$$

where q is the speed of mean reversion, m is the long run mean of the interest rate, v is the volatility of interest rates, W is a standard Brownian motion, and the correlation between the shocks to interest rates and firm asset value is ρ, i.e., $\mathrm{E}[(dZ)(dW)] = \rho\,dt$.[8] This correlation determines the interest rate sensitivity of assets, i.e., asset duration.

Finally, extending Merton (1974), we assume that the firm's claims are separated into three classes of financial assets: equity, denoted E; zero-coupon senior debt with face value K_S, denoted D_S; and zero-coupon junior debt with face value K_J, denoted D_J. We assume that the senior and junior debt issues have the same maturity τ. Under these assumptions, and under a strict absolute priority rule, it is well known that the prices of these financial assets can be expressed in terms of options on the underlying assets of the firm and a default-free zero-coupon bond.

To obtain closed-form expressions for the values of these corporate securities, we begin by using results from Merton (1973), Rabinovitch (1989), Shimko et al. (1993), and Schaefer and Strebulaev (2008) to write the price of a put option written on the firm's assets as

$$P(V,r;K) = KB(r)N\big(-d_2(V,r;K)\big) - VN(-d_1(V,r;K))\ , \qquad (1)$$

[7] The effects of risk premia are negligible for the results that follow, so for ease of exposition all calculations are done under the risk-neutral measure.

[8] Many of the pricing results to follow can be derived under much more general assumptions about the processes for asset values and interest rates, such as a k-factor affine term structure model. See, for example, Acharya and Carpenter (2002), Schaefer and Strebulaev (2008), and Huang and Shi (2016). The assumptions here, however, allow for a simple presentation of the relevant economic intuition.

where

$$d_1(V,r;K) = \frac{\ln\big(V/\big(KB(r)\big)\big) + T/2}{\sqrt{T}} \qquad d_2(V,r;K) = d_1(V,r;K) - \sqrt{T}$$

$$T = \sigma^2\tau + (\tau - 2C + (1 - e^{-2q\tau})/(2q))(v/q)^2 - (2\rho\sigma(\tau - C)v)/q$$

$$B(r) = Ae^{-rC}$$

$$A = e^{k(C-\tau)-(vC/2)^2/q} \qquad k = m - (v/q)^2/2 \qquad C = \ (1 - e^{-q\tau})/q\ ,$$

and where K is the strike price, τ is the maturity of the option, $B(r)$ is the price of a default-free zero-coupon bond of the same maturity τ, $N(\cdot)$ is the cumulative normal distribution function, and we suppress functional dependence on the parameters τ, σ, q, m, and v for brevity. It follows that the values of the corporate securities are

$$\begin{aligned} D_S(V,r;K_S) &= K_S B(r) - P(V,r;K_S) \qquad (2) \\ &= K_S B(r) N\big(d_2(V,r;K_S)\big) + VN(-d_1(V,r;K_S)) \\ E\big(V,r;K_S,K_J\big) &= V + P\big(V,r;K_S + K_J\big) - \big(K_S + K_J\big)B(r) \\ &= VN\left(d_1\big(V,r;K_S + K_J\big)\right) - \big(K_S + K_J\big)B(r)\,N\left(d_2\big(V,r;K_S + K_J\big)\right) \\ D_J\big(V,r;K_S,K_J\big) &= V - D_S(V,r;K_S) - E\big(V,r;K_S,K_J\big) \\ &= \big(K_S + K_J\big)B(r)N\left(d_2\big(V,r;K_S + K_J\big)\right) - K_S B(r) N\big(d_2(V,r;K_S)\big) \\ &\quad + V\left[N\big(d_1(V,r;K_S)\big) - N\left(d_1\big(V,r;K_S + K_J\big)\right)\right] \end{aligned}$$

Senior debt equals a default-free zero-coupon bond minus a put option on the underlying assets with an exercise price equal to its face value K_S. Equity is simply the value of the assets minus the value of risky-zero coupon debt with a face value equal to $K_S + K_J$. Junior debt makes up the balance of firm value. The key insight is that equity includes a short position in the underlying debt and therefore tends to have negative duration. More subtly, junior debt exhibits a similar phenomenon as it, and the senior debt above it, become sufficiently risky.

Throughout, we will define duration as the negative of the percent change in the value of the security for a change in the interest rate, which is the negative of the slope coefficient in the regressions we run later of security returns on interest rate changes.[9] This quantity determines the

[9] Since we are working with a one-factor interest rate model, we could easily redefine this duration with respect to the change in yields on risk-free bonds at any maturity with similar results.

size of the short position in government bonds necessary to hedge the interest rate exposure of the security. Under this definition, the duration of the firm's assets is (see the Appendix for details)

$$M_V = -\frac{\rho\sigma_V}{v}\,. \tag{3}$$

For the financial claims on these assets, the durations are

$$\begin{aligned} M_S &= -\frac{\partial D_S}{\partial r}\frac{1}{D_S} + \frac{\partial D_S}{\partial V}\frac{V}{D_S}M_V \\ M_J &= -\frac{\partial D_J}{\partial r}\frac{1}{D_J} + \frac{\partial D_J}{\partial V}\frac{V}{D_J}M_V \\ M_E &= -\frac{\partial E}{\partial r}\frac{1}{E} + \frac{\partial E}{\partial V}\frac{V}{E}M_V\,. \end{aligned} \tag{4}$$

The durations of the contingent claims consist of two components. The first is the interest rate sensitivity of the claim holding asset value fixed, which is the quantity of primary interest. The second is the asset duration multiplied by the elasticity of the claim value with respect to the value of the assets, which captures the transmission of asset duration to the contingent claim. Note that from equation (2),

$$-\frac{\partial D_S}{\partial r} = -K_S\frac{\partial B}{\partial r}N\big(d_2(V,r;K_S)\big) > 0 \tag{5}$$

$$-\frac{\partial E}{\partial r} = (K_S + K_J)\frac{\partial B}{\partial r}N\Big(d_2\big(V,r;K_S + K_J\big)\Big) < 0\,. \tag{6}$$

In other words, if asset duration is small, than senior debt has positive duration and equity has negative duration. On the other hand,

$$-\frac{\partial D_j}{\partial r} = -(K_S + K_J)\frac{\partial B}{\partial r}N\Big(d_2\big(V,r;K_S + K_J\big)\Big) + K_S\frac{\partial B}{\partial r}N\big(d_2(V,r;K_S)\big)\,, \tag{7}$$

which can be of either sign. Indeed, as K_S grows small, junior debt becomes senior debt, while as K_J grows large, junior debt becomes equity.

To illustrate how durations vary across firms and priority levels, Figure 1 graphs the durations of senior debt, junior debt and equity as functions of firm asset value for various values of asset duration, i.e., for various values of the correlation ρ. Since the face value of the debt is fixed, asset value is a proxy for both the degree of leverage and the riskiness of the debt.

Several observations are in order. First, when the value of the assets V grows large relative to the face amount of the debt $K_S + K_J$, the durations of senior and junior debt both converge to the duration of a default-free bond with the same maturity,[10] and equity duration converges to asset duration. Conversely, as asset value falls, senior debt duration converges to asset duration.

Second, Figure 1 suggests there is a general ordering of durations from senior debt to junior debt to equity. The direction of this ordering depends on whether the duration of the assets exceeds that of the senior debt when it is risk-free. If it does not, which we consider to be the more likely case empirically, then duration declines as the claim becomes more junior, as illustrated in the first three panels in Figure 1.

Moreover, more negative asset durations increase the spread in duration between the claims. Note also that equity duration can change sign from negative to positive as leverage decreases, i.e., as asset value increases, when asset duration is positive, as in the third panel. The same is true for junior debt, and even senior debt if asset duration is negative. In the extreme case depicted in the fourth panel, when the asset duration exceeds the duration of the risk-free senior debt, the ordering of durations is reversed. The asset duration effect dominates and the lower priority claims are more exposed to this effect because they have larger elasticities with respect to the assets.

Since the duration of a portfolio of financial assets is just a market value-weighted average of the durations of these assets, popular indexes such as the S&P 500, the Dow Jones 30, and various corporate bond indexes will take on the sensitivities of the underlying financial assets. Therefore, Figure 1 shows that there is naturally a negative relation between stock index returns and government bond returns induced by the capital structure of firms. The magnitude of this negative relation will depend on firms' leverage ratios; however, as shown above, it will also be affected by the duration of the underlying assets. It is worthwhile commenting on the source of this duration.

From an ex ante point of view, it is not clear what the value of asset duration should be. Consider a standard, representative agent, consumption-based equilibrium model with i.i.d.

[10] The duration of a default-free zero-coupon bond is less than its maturity because we define duration relative to the instantaneous interest rate, which is mean reverting in the Vasicek model, rather than relative to the yield on the bond. Because of mean reversion, longer-term yields move less that the instantaneous rate.

consumption and dividend growth and money neutrality, i.e., no real effects of inflation. In this setting, real asset returns are a function of contemporaneous consumption growth and real interest rates are constant. With money neutrality, the Fisher effect holds, and nominal asset values increase with inflation (for example, see Fama and Schwert (1977) and Boudoukh and Richardson (1994)). Nominal asset returns therefore move one for one with current inflation. If inflation is persistent, however, an increase in inflation will also lead to an increase in expected inflation in the same direction, leading to an increase in nominal interest rates. Thus, in this standard framework, there is a positive correlation between interest rates and asset values or, in other words, a tendency towards negative duration.

There are reasons why this result may not hold in a more complex setting, and while early empirical work such as Fama (1975) is consistent with constant real rates, updates on these studies such as Fama (2019) strongly suggest significant variation in both expected inflation and expected real rates. There is also a well-known literature that argues that inflation negatively covaries with real economic activity, thus leading to a negative relation between nominal asset values and inflation (e.g., see Fama (1981), Boudoukh, Richardson, and Whitelaw (1994), Bekaert and Engstrom (2010), and Campbell, Sunderam, and Viceira (2013)). In this case, changes in inflation could lead to changes in the opposite direction in nominal interest rates and asset values. More generally, there is now an extensive literature that models the joint behavior of asset prices and interest rates in dynamic consumption-based asset pricing models (e.g., Barsky (1989), Campbell and Cochrane (1999), and Koijen, Lustig, and Van Nieuwerburgh (2017), among others). While many of these models also produce results more consistent with negative asset durations, it is possible to generate the opposite result (e.g., Shiller and Beltratti (1992) and Campbell, Sunderam, and Viceira (2013)).[11]

B. Main Regression Specification and Hypothesis Development

Recall from equation (4) that the duration of a corporate claim consists of two parts: (i) the interest rate sensitivity of the claim, holding asset value fixed, and (ii) the interest rate sensitivity of the assets multiplied by the elasticity of the claim with respect to the assets. The former effect

[11] Note that these papers do not model the value of equity as a contingent claim on the underlying assets of the firm. Thus, one could interpret these papers as pricing unlevered equity or equivalently the assets of the firm.

is our primary focus. To control for the latter effect in our empirical analysis, note that for a generic security with value *D,*

$$\frac{dD}{D} = \frac{\partial D/D}{\partial r} dr + \frac{\partial D/D}{\partial V/V} \frac{dV}{V} + dt \text{ terms} . \tag{8}$$

We treat variation in the dt terms as negligible relative to variation in the dr and dV terms. Therefore, the regression specification for estimating duration becomes

$$R_t = \alpha + \frac{\partial D/D}{\partial r} \Delta i_t + \frac{\partial D/D}{\partial V/V} RA_t + \varepsilon_t , \tag{9}$$

where Δi_t is the change in interest rate and RA_t is the return on the assets of the firm.

The theoretical results in Section II.A show that what matters for a security's interest rate sensitivity is the leverage of the firm, the priority of the security within the firm, and the duration of the assets.[12] Therefore, we implement a natural functional form for equation (9) that incorporates the asset return effect, as well as leverage (*L*) and priority (*P*). For bonds, our specification is,

$$R_{t+1} = \alpha + \beta_t \tau_t (-\Delta i_{t+1}) + \theta_t RA_{t+1} + \epsilon_{t+1} , \tag{10}$$

where β_t and θ_t are parameterized as

$$\beta_t \equiv \beta_0 + \beta_1 L_t + \beta_2 P_t + \beta_3 L_t P_t + \beta_4 Z_t$$
$$\theta_t \equiv \theta_0 + \theta_1 L_t + \theta_2 P_t ;$$

τ_t is the average cash flow life of the bond; L_t is the leverage of the firm, defined as log book debt divided by market assets; P_t is the priority of the bond, defined as one minus the fraction of the face value of the bonds that are senior to that bond; Z_t is a set of dummy variables for callable, convertible, putable, floating rate and asset-backed bonds; RA_{t+1} is the return on the firm's assets; and Δi_{t+1} is the change in the five-year CMT yield.[13] For riskless, zero-coupon bonds, duration approximately equals maturity, and the coefficient β_t should be approximately one. Thus, we are estimating the multiplicative effect of leverage and priority on this baseline duration for risky debt.

[12] Other parameters are also potentially important, such as the volatility of the firm's assets, as these parameters help determine the probability of default.

[13] A few observations are in order. First, seniority is determined by the relative ratings of bond issues within the firm cross-checked with the individual bond data. Second, because so many bonds have option-like characteristics, we choose to include them with a dummy variable as opposed to dropping them. Finally, the five-year Treasury yield was chosen to avoid any issues related to money market rates. By only including a single interest rate, we are effectively imposing a one-factor model. Huang and Shi (2016) show that including multiple interest rate factors can help capture and hedge the interest rate risk of senior debt, but our focus is on the effects of priority structure and leverage.

For equity, the value of our priority variable is always zero, so we estimate a slightly simplified version of equation (10), where we drop the priority terms P_t and L_tP_t, as well as the average cash flow life τ_t and the bond type controls Z_t. In this case, the coefficient β_t is the duration of equity, and equation (10) estimates the effect of leverage on this duration. For assets, we further drop the asset return term, and equation (10) estimates the correlation between leverage and asset duration with no causality implied.

Equations (5), (6) and (7) imply that $\beta_t > 0$ for senior debt, $\beta_t < 0$ for equities, and β_t can be of either sign for junior debt. Figure 1 suggests that when we control for asset duration, or when asset duration is close to zero, β_t is decreasing in leverage, i.e., $\beta_1 < 0$, and β_t is increasing in priority, i.e., $\beta_2 > 0$. However, when asset duration is greater than the maturity of the highest priority debt and we do not control for asset duration, Figure 1 suggests that β_t is increasing in leverage, i.e., $\beta_1 > 0$, and β_t is decreasing in priority, i.e., $\beta_2 < 0$.

III. Data Description

To test the hypotheses developed above, we first map out capital structures and construct security returns for as many firms as possible, using data from a wide variety of sources. We merge data from CRSP for equity prices, the Bridge EJV database from Reuters for corporate bond prices and details,[14] the FISD from Mergent for additional corporate bond details and verification of the EJV data, Dealscan and the mark-to-market pricing services from Loan Pricing Corporation (LPC) for loans, Compustat for the face value of debt and other accounting information, and Bloomberg for fact checking discrepancies. The construction of the asset return series and the description of the data are provided in detail in Choi (2013), and these same data underlie the analysis of equity return volatility and leverage in Choi and Richardson (2016). Therefore, we only summarize the data and stylized facts relevant for our study.

Our dataset is comprehensive. Our sample includes 96% of all bond and loan issues in the CRSP/Compustat universe and 90% of the debt on a value-weighted basis. A little over one-third

[14] Each day, the bid and ask prices are gathered from dealers in the marketplace and then aggregated to one set of bid and ask prices. As an indication of the importance of the Bridge EJV database in the corporate bond market, most participants use this database to mark their books each day. The bond data requires substantial cleaning, involving issues such as duplication via 144a issuances, staleness and matrix pricing. Choi (2013) provides a detailed analysis of these issues.

of the debt is in the form of loans. Table 1 provides summary statistics on the sample distributions of debt priority and leverage, key theoretical determinants of interest rate sensitivity. Panel A documents the distribution of the number of debt priority levels. Specifically, 66% of the observed capital structures contain bonds of just one priority while 21% have two, 7% three, and 6% four or more. Panel A further breaks down each multi-priority capital structure into low and high priority components and types of bonds as a percentage of total assets. On average for each firm, there is a nice mix of high and low priority bonds, with the majority of bonds having fixed coupon rates. Panel B provides the distribution of firm leverage. For example, half of the observations have market debt to equity ratios greater than 0.45.

Under the assumptions of Modigliani and Miller (1958), we can calculate the return on the firm's assets as the market value weighted average of the return on its underlying financial claims. In order to calculate these returns, we use the firm's liability structure and the corresponding prices and interim payments of the underlying securities.[15] Note that our datasets map out financial liabilities of firms and do not cover non-financial liabilities such as trade credit and account payables. Our measures of asset returns are still good proxies for true asset returns, as these other liabilities are typically small and show little change in value over time.

As for the individual components of the capital structure, equity returns are calculated in the usual way as next period's price plus any dividends paid divided by the current price. Bond returns are calculated similarly each period from quoted bond prices, coupon payments and accrued interest.[16] The more tricky calculations are the returns on bank loans. On the positive side, because bank loans reside towards the top of the capital structure (at least until quite recently), their price variation is not particularly large.[17] For the sample period in which the loan data are coincident

[15] As shown in Table 1, only a portion of debt comes in the form of publicly traded bonds. A considerable portion consists of bank loans. The major sources for the bank loan data are Dealscan, going back to 1987, and, for the pricing and more detailed characteristics of the loans, the Loan Syndications and Trading Association (LSTA) and the LPC. There have been some analyses of the quality of the pricing data, most notably Taylor and Sansone (2007). The main conclusion is that, at least for cases where traded prices are available, the average dealer marks are representative. Two drawbacks of the bank loan data are that (i) they are available over a much shorter time period, and (ii) active volume, and thus reliable secondary prices, exist only for leveraged loans. Of course, bank loans of investment grade firms tend to trade around par if their coupon rates float.

[16] When a bond price is missing in a particular month, which occurs in less than 1% of the sample, we interpolate the price assuming it changes in relative proportion to other bonds of the firm, the relative change being determined by its relative duration.

[17] See, for example, Altman and Stonberg (2006) and Acharya, Hasan, and Saunders (2006) who document very high recovery rates on bank loans and thus low losses given default.

with the bond data, loan returns are calculated using loan prices and the interest payments over the month. Prior to November 1999, and for a number of firms not covered in the loan pricing dataset, we need to use an alternative approach for generating loan returns. Specifically, since both the bonds and loans can be viewed as contingent claims on the firm's assets, we run a panel regression, broken down by firm ratings, of the excess return on a firm's bank loans against the excess return on the firm's bond portfolio and Treasuries of similar duration to the bonds. These coefficients are then used to matrix price the loans of firms in periods when bank loan data are not available.[18]

IV. Firm-Level Evidence on the Duration of Corporate Securities

In this section we investigate the implications of equation (4) and Figure 1 at the individual firm level. First, we present simple estimates of corporate security durations for subsamples of firms grouped by leverage. Then we test for differences in duration between high and low priority securities within firms. Finally, we estimate the duration of a particular security as a function of its priority in the capital structure as specified in equation (10).

A. Simple Duration Estimates for Securities Grouped by Firm Leverage

As a first pass, Table 2 summarizes simple estimates of duration for different classes of securities of firms grouped by leverage, where leverage is defined as the market value of assets relative to debt outstanding. There are five leverage groups, a zero leverage group, and four leverage quartiles. To be included in one of the four groups of levered firms, firms are required to have both high and low priority bonds that are neither convertible nor callable and have at least three years to maturity and value greater than 10% of the value of firm's total debt. We estimate the following equation for four types of corporate claims: senior debt, junior debt, equity, and firm assets:

$$R_t^i = \alpha + \beta(-\Delta i_t) + \varepsilon_t \ . \tag{11}$$

Note that equation (11) is a simplified version of equation (10). We estimate equation (11) separately for each of the five leverage groups in order to yield non-parametric estimates of the effect of leverage on duration. For firms with multiple bond issues in a given priority level, the dependent variable for that debt class is the value-weighted average of the returns on these bonds.

[18] The results are robust to various specifications, most probably due to the relatively low volatility of bank loan returns.

Consistent with our theoretical predictions, duration decreases with priority in each of the four subsamples that contain levered firms. For example, for the lowest leverage quartile, duration decreases from 2.9 for high priority bonds to 2.2 for low priority bonds to -1.7 for equity. Similarly, for the highest leverage quartile, duration declines from 0.8 to 0.6 to -2.1.

The results in Table 2 also confirm other implications of our theory.[19] First, equity has negative duration in all leverage groups. This finding at the firm level is not discussed in the existing literature, but it follows directly from equity's location as the lowest priority security in the capital structure. Second, because asset durations vary with leverage across firms, it is difficult to compare the durations of securities across firms that fall into different leverage ranges, yet a key result does emerge. Consistent with the theory, bond duration declines with leverage. For example, as we go from the lowest to the highest leverage quartile, the duration of senior debt declines from 2.9 to 2.5, 2.1 and 0.8, while the duration of junior debt declines from 2.2 to 2.1, 1.5 and 0.6. Finally, as explained in Section II.A, equity duration is related to asset duration. In Table 2, equity duration is hump-shaped across the leverage groups, mirroring the pattern in asset duration. This result shows the importance of taking into account the characteristics of the assets when examining the durations of corporate securities.[20]

B. Within-Firm Differences in Durations of High and Low Priority Securities

One way to control for the effect of differing asset duration across firms is to compare returns across securities within a firm.[21] Thus, we estimate the regression

$$R_{t+1}^{m} - R_{t+1}^{n} = \alpha + \beta(-\Delta i_{t+1}) + \gamma(\tau_t^m - \tau_t^n)(-\Delta i_{t+1}) + \epsilon_{t+1}\,, \tag{12}$$

where $R_{t+1}^{m} - R_{t+1}^{n}$ is the difference in returns between two securities issued by the same firm, with security *m* being lower priority than security *n*, and $\tau_t^m - \tau_t^n$ is the difference in the average cash flow life of the two securities. When R_{t+1}^{m} is an equity return, R_{t+1}^{n} represents the return on all of the fixed-rate bonds of the firm and τ_t^m is set to zero. We are primarily interested in the coefficient

[19] Note that these durations are calculated relative to the five-year CMT yield. Our theoretical analysis focuses on durations relative to the instantaneous yield. In a one-factor interest rate world, these durations are closely related but the exact relation depends on the parameters of the interest rate process, in particular the speed of mean reversion (see Section II.A).
[20] The average returns and volatilities of the groups of corporate securities also reveal interesting features of the data that speak to both contingent claims pricing and firms' capital structure decisions. However, since these results are tangential to the focus of the paper, they are relegated to the Online Appendix.
[21] Of course, the control will only be partial due to the securities' different elasticities with respect to the assets.

β, which measures the difference in duration between the two securities of different priority. We include the interaction term with the difference in average cash flow life to control for the effects of maturity and coupon rate on bond duration.

Table 3 reports the results from the estimation of equation (12) and again confirms the main implications of our theory. The β coefficient estimates are negative and highly statistically significant, i.e., lower priority debt issues within the firm have a lower duration. Controlling for differences in average cash flow life barely changes this coefficient estimate, although γ is positive, indicating that longer maturity bonds have higher durations as expected. In addition, Table 3 confirms that equity has lower duration than the fixed rate bonds of the same firm. The magnitude of this effect is large, i.e., -1.5, consistent with equity being effectively short the bonds due to its location within the priority structure.

C. Estimates of Duration as a Function of Leverage and Priority

Whereas Tables 2 and 3 provide initial support for our theoretical predictions, this subsection presents the full estimation of equation (10). Recall that the theory says that leverage and priority have unambiguous effects when we control for asset duration: $\beta_t < 0$ for equities, $\beta_t > 0$ for senior debt, $\beta_1 < 0$ for all securities and $\beta_2 > 0$ for debt securities.

Table 4 reports pooled estimation results for the durations of corporate bonds, in Panel A, and equity, in Panel B. Consider the results in the first column of Panel A from a specification that excludes the return on assets. Not surprisingly, the estimate of β_0 is significantly positive, indicating that duration increases with maturity. On the other hand, the estimate of β_1 is significantly negative, i.e., duration decreases with leverage. Most novel, the estimate of β_2 is significantly positive, that is, higher priority bonds have higher duration. In addition to being statistically significant, the estimates are economically meaningful. For example, the average maturity of the bonds in our sample is approximately 6 years; therefore, the seniority of high priority bonds contributes around 0.66 to their duration. We also find that the interaction between leverage and priority is positive and highly statistically significant, showing that the effect of priority on duration becomes stronger as leverage increases. These results explain, at least in part, why structural models that ignore the priority structure of debt do not capture the interest rate sensitivity of corporate bonds.

Column 2 of Panel A presents the results for the estimation of equation (10), controlling for asset returns. As expected, the returns on corporate bonds load positively on asset returns,[22] but including these returns in the specification does not materially alter the estimated effects of leverage and priority on duration. This result reflects the combination of relatively small asset duration and low elasticities of these securities with respect to the assets.

As discussed in Section I, Duffee (1998) and Schaefer and Strebulaev (2008) document that duration falls as credit ratings decline. Because credit rating agencies use inputs such as leverage and priority, it is worthwhile to consider how the results of Panel A change if we add credit ratings to the regression, which we do in columns 3 through 7. We incorporate credit ratings in two ways. First, in column 3, we add both indicator variables for ratings categories and these same indicator variables multiplied by $\tau\Delta i$. In column 4, we use the same ratings fixed effects but drop leverage and priority. In columns 5 and 7, rather than multiplying $\tau\Delta i$ by indicator variables for each ratings category, we multiply by a ratings variable that decreases as ratings decline.[23] In columns 6 and 7 we replace asset returns by equity returns to mimic Schaefer and Strebulaev (2018).

Several observations are in order. First, adding credit rating fixed effects to the regression, as we move from column 2 to column 3, provides no increase in explanatory power, i.e., the R^2s are essentially the same. Second, the coefficient on priority barely moves from 0.098 to 0.099. The coefficient on priority times leverage increases from 0.028 to 0.043, but the coefficient on leverage increases from -0.061 to 0.002, becoming insignificant. Third, when leverage and priority are dropped from the regression, as we move from column 3 to column 4, the R^2 falls from 25% to 21%, implying that credit ratings are not sufficient for explaining duration. The R^2 declines further, to 17%, when equity returns replace asset returns in columns 6 and 7. Fourth, the different specification of credit ratings does not seem important to the regression model as columns 4 and 6 give similar results to columns 5 and 7. As a whole, these results provide evidence that the effect of capital structure priority is significant and not captured fully by credit ratings.

[22] These results are broadly consistent with those of Schaefer and Strebulaev (2008), who show that the sensitivity of corporate bond returns to changes in the value of equity are in line with the implications of structural credit risk models. For example, the sensitivity of bond returns to asset returns increases as leverage increases, as these models would predict.

[23] We use numerical values for *Ratings*, i.e., AAA=24, AA+=23, AA = 22, and so on.

As a final comment on the Schaefer and Strebulaev (2008) specification, note that with regard to their conclusion that the duration of corporate bonds is too low, one possible explanation is mis-specification of the model as evidenced by the drop in R^2 from 25% to 17% as we go from our model in column 3 to theirs in column 6. Comparing the duration estimates from these models provides some insight into this question. Specifically, evaluating the estimate of the total duration coefficient β_t at median leverage and priority levels for each ratings class yields 0.35, 0.37, 0.37, 0.35, 0.31, 0.18 and 0.03 for AAA, AA, A, BBB, BB, B and CCC, respectively, for our model in column 3, compared to 0.35, 0.35, 0.34, 0.32, 0.26, 0.14 and -0.03 for Schaefer and Strebulaev's (2008) specification in column 6. Note that the inclusion of leverage and priority makes the most difference for the high yield bonds, as expected.

Panel B of Table 4 presents duration estimates for equity. For equity, the results in column 1, in which we again exclude the return on assets, appear to present a conundrum. The estimate of the total duration coefficient β_t is positive, in contrast to the preliminary equity duration estimates in Table 2. However, the regression does not control for the effect of asset duration. For non-zero asset duration, we have an omitted variables problem, and, because interest rate changes and asset returns are correlated, interest rates will proxy for the underlying asset returns in the regression.

Column 2 of Panel B presents the results for the estimation of equation (10), controlling for asset returns. As expected, the returns on stocks load positively on asset returns. More interesting is the effect of including asset returns on the duration estimates. The duration estimate becomes significantly negative. Moreover, the effect of leverage on duration is also significantly negative, as predicted. Thus, the results strongly support the capital structure priority theory of the duration of equity, i.e., equity duration is negative and more so for highly levered firms.

D. Duration Estimates for Corporate Securities Grouped by Asset Duration

A novel implication from Figure 1 is that, when assets have duration greater than the maturity of the debt, the durations of all corporate securities are positive, and the effect of leverage is reversed, that is, durations of corporate securities increase with leverage. In addition, under this same condition, the ordering of these durations with respect to priority is also reversed, with equity having the highest duration and senior debt having the lowest. To investigate these implications, we break the sample of firms into terciles based on asset duration and run simplified versions of equation (10), in which we eliminate asset returns. For bonds we estimate the regression

$$R_{t+1} = \alpha + \beta_t \tau_t(\Delta i_{t+1}) + \epsilon_{t+1} \tag{13}$$
$$\beta_t = \beta_0 + \beta_1 L_t + \beta_2 P_t + \beta_3 L_t P_t + \beta_4 Z_t \ .$$

We predict that when firms have sufficiently high asset duration, $\beta_t > 0$, $\beta_1 > 0$ and $\beta_2 < 0$. For equity, we drop maturity and priority from the specification, and we predict that, under the same circumstances, $\beta_t > 0$ and $\beta_1 > 0$.

Table 5 reports the results. Consistent with the hypotheses for bonds above, the estimate of the coefficient β_1 in Panel A increases with asset duration and becomes positive for the highest asset duration tercile. At the same time, the estimate of the coefficient β_2 decreases with asset duration, becoming statistically indistinguishable from zero, though not negative, for the highest asset duration tercile. As for equity, the results in Panel B also support the hypotheses above. Specifically, the estimate of the total duration β_t becomes positive as asset duration increases, and this duration estimate is increasing in leverage.

In the analyses in Sections IV.C and IV.D, the priority variable is constructed using both fixed and floating rate bonds, although it excludes bank loans. The logic for excluding bank loans is that as senior, floating rate securities, they have durations very close to zero, and thus they have little direct effect on the durations of the securities below them in the capital structure. However, they are included in the measure of leverage, since they directly affect the probability of default. The same might be true of floating rate bonds, although, being below bank loans in priority, they are likely to be subject to more default risk. As a robustness check, we also exclude floating rate bonds in constructing the priority variable. In results provided in the Online Appendix, we find qualitatively similar results, showing that the results in Tables 4 and 5 are robust.

V. The Correlation between Stock and Bond Index Returns

There is a large literature documenting the comovements of stock and government bond returns (e.g., Campbell and Ammer (1993), Fama and French (1993), Connolly, Stivers and Sun (2005), Baele, Bekaert, and Inghelbrecht (2010), Baker and Wurgler (2012), Baele, Bekaert, Inghelbrecht and Wei (2013), Campbell, Sunderam, and Viceira (2013), Bansal, Connolly and Stivers (2014), Goyenko and Sarkissian (2014), Campbell, Pflueger and Viceira (2015), and Chiang, Li and Yang

(2015)). The basic finding is that this relation varies over time. These and other authors focus on explanations that depend on time-varying shocks either to the real economy and inflation or to liquidity, uncertainty, or aggregate behavioral phenomena. The surprising finding is that the apparent driving forces behind this time-varying correlation are not macroeconomic fundamentals, but factors related to liquidity and flights to safety.

However, this literature ignores capital structure effects on stock-bond correlations. The theory of Section II and the empirical analysis of Section IV show the importance of both leverage and priority in determining interest rate sensitivity and thus have direct implications for the duration of stock and bond indexes. In particular, because portfolio returns are weighted averages of individual security returns, weighted averages of portfolio leverage and priority should help explain the durations of portfolios. Using this insight, this section sheds new light on the dynamics of the correlation between equity portfolio returns or corporate bond portfolio returns and government bond returns.

First, consider the index return, $R_{p,t+1} \equiv \Sigma_i w_{it} R_{i,t+1}$, where w_{it} is the weight of a particular corporate security in the index. To motivate the empirical analysis to follow, use equation (10) to substitute in for the returns, and assume that the underlying assets of the firms have zero duration and time to maturity is uncorrelated with the other predictor variables. Then the correlation between the index return and interest rate changes can be written as:

$$corr\left(R_{p,t+1}, -\Delta i_{t+1}\right) = \left[\left(\beta_0 + \beta_1 \overline{L_{it}} + \beta_2 \overline{P_{it}} + \beta_3 \overline{L_{it} P_{it}} + \beta_4 \overline{Z_{it}}\right)\overline{\tau_{it}}\right] \frac{\sigma(\Delta i_{t+1})}{\sigma(R_{p,t+1})}, \qquad (14)$$

where $\overline{L_{it}}, \overline{P_{it}}, \overline{L_{it} P_{it}},$ and $\overline{\tau_{it}}$ are, respectively, the weighted average values of leverage, priority, leverage times priority, and maturity of the securities in the index.[24]

Clearly, the average leverage of the firms and the average priority of the corporate securities in the index play a role in determining the correlation between the index return and interest rate changes. For example, ceteris paribus, given that $\beta_1 < 0$, equation (14) shows that higher average

[24] The theoretical results described in Section II, the Online Appendix and Figure 1 describe the duration of corporate securities. Most of the work using aggregate indexes focuses on the correlation between security returns and government bond returns. While closely related, durations and correlations are obviously not the same, differing by an effect associated with the relative volatilities of the returns. Because the volatilities of the securities themselves depend on leverage and priority, some interesting dynamics emerge. The calculations and corresponding figures are provided in the Online Appendix.

firm leverage reduces the correlation between corporate security index returns and government bond returns. In addition, equation (14) shows that because $\beta_2 > 0$, the correlation of index returns with government bond returns is larger the higher the average priority of the securities within the index. None of the aforementioned literature accounts for the fact that equity is generally short fixed rate debt and low priority corporate bonds are in the middle of the capital structure in terms of priority. Thus, we add to this literature by showing how much of the time variation in stock and bond index return comovements can be explained by leverage and priority.

A. Equity Index Returns and Government Bond Returns

Figure 2 graphs estimates of an aggregate inverse leverage measure and the correlation between the returns on equity and government bonds over the period 1985-2012. The correlation is estimated using a 36-month rolling window of equity index returns and five-year CMT returns. We take the value-weighted average of equity returns on our sample firms to construct the equity index returns.

The figure produces the well-known stylized fact that this stock-bond correlation switches sign from positive to negative during the early 2000s, a phenomenon which has been a focal point of the literature. Not addressed in this literature, but key to the thesis of this paper, there appears to be a close relation between the comovement of stock and government bond returns and the degree of leverage in the economy. The correlation between the inverse of aggregate leverage and the correlation between equity and government bond returns is 0.54. Moreover, the change in the sign of stock-bond correlation around 2000 coincides with a surge in the average leverage of firms. These findings suggest that any model developed to explain the comovement of equity returns and interest rate changes must include the fact that equity is effectively short fixed rate debt.

That said, leverage alone cannot explain the level of the stock-bond correlation. Leverage was also high in the late 1980s and early 1990s, yet this stock-bond correlation was positive in this period. We partially resolve this puzzle by accounting for the incremental effect of asset duration on stock-bond comovement. Specifically, we construct asset-neutral equity returns as $R^e_{p,t+1} \equiv \Sigma_i w_{i,t}\left(R_{i,t+1} - \theta_{i,t} RA_{i,t+1}\right)$, where $\theta_{i,t}$ is the estimated elasticity of equity with respect to assets as in equation (10). By removing the sensitivity of equity to the return on the underlying assets, we can better isolate the effect of leverage on the correlation between the returns on equity and government bonds.

Some insights emerge from examining the correlation between the returns on government bonds and asset-neutral equity. First, the time-series pattern of the rolling correlations better matches the pattern of the average leverage, with an even higher correlation of 0.62. Second, over the entire 30-year sample period, the estimated correlation between aggregate stock returns and government bond returns is virtually always negative after adjusting for asset returns, as predicted by equation (6). The standard error of the 36-month rolling correlations under an assumption of multivariate normality is $\sqrt{(1-\rho^2)/34}$, which ranges between 0.14 and 0.17 depending on the true correlation ρ. Thus, the large negative correlations between stock and government bond returns, especially in the latter part of the sample, are significantly different from zero. Finally, the correlation between government bond and equity returns exceeds the correlation between government bond returns and asset-adjusted equity returns throughout the entire period. This implies that asset duration was positive throughout the sample period and especially high in the first half of this period.

While the evidence in Figure 2 provides strong support for our theory, it does not control for other variables that affect the correlation. For example, Baele, Bekaert, and Inghelbrecht (2010) use a variety of variables including macroeconomic factors such as interest rates, inflation and the output gap, as well as measures of changing risk aversion and proxies for liquidity to explain time variation in stock-bond correlations. Their basic finding is that macroeconomic factors play little role and that "non-fundamental" factors such as liquidity are more important.

We perform an analysis similar to that in Baele, Bekaert and Inghelbrecht (2010), but we include aggregate leverage as an additional factor. Specifically, we regress the 36-month rolling correlation between equity and government bond returns on measures of market illiquidity, uncertainty, and risk premiums in addition to aggregate leverage.[25] For this analysis, aggregate

[25] The stock market illiquidity measure is the market value-weighted frequency of zero daily returns within a month across all firms, while bond market illiquidity is measured by a monthly average of quoted bid-ask spreads. We also include the interaction between these two illiquidity measures to capture any comovement effects of market illiquidity. In addition to these illiquidity measures, we include VIX to measure market uncertainty, and the dividend yield, default spread, term spread, and T-bill rates in order to capture the effect of time-varying risk premiums on the bond-equity correlation as in Baele, Bekaert, and Inghelbrecht (2010).

leverage is calculated as the ratio of aggregate book debt to market assets (BDMA). All the explanatory variables are standardized to facilitate assessments of economic significance. The sample starts in 1990, when VIX becomes available.

Table 6 reports the results. Column 1 presents the results of regressing the rolling correlation between equity index returns and government bond returns on the leverage of the index, while Column 5 presents the results of the same regression with asset-neutral equity index returns replacing the original equity index returns. Consistent with our theory, the coefficient on leverage is negative and statistically significant in these regressions, with adjusted R^2s of 27% and 39%, respectively. [26] For example, a one-standard-deviation increase in leverage decreases the government bond-equity correlation by 0.2. When controls for either asset volatility (see equation (14) and the Online Appendix) or Baele, Bekaert and Inghelbrecht's (2010) set of liquidity and macro variables are included, the coefficient on the leverage variable is still negative and statistically and economically significant. These results strongly support the conclusion that firm leverage plays an important role in explaining the correlation between aggregate equity index returns and government bond returns.

However, while the empirical methodology is somewhat different than Baele, Bekaert and Inghelbrecht (2010), we also broadly confirm their results on the importance of liquidity. When we include liquidity controls, the adjusted R^2 jumps from 39% in Column 2 to 55% in Column 3 and from 32% in Column 6 to 44% in Column 7. This finding shows why aggregate firm leverage in Figure 2 does not explain the entire shift from positive to negative correlations during the late 1990s. Liquidity also plays a key role. As Baele, Bekaert and Inghelbrecht (2010) also document, macro-related fundamentals do not seem to affect the aggregate equity-government bond correlation. Indeed, the adjusted R^2s either stay the same or drop in Columns 4 and 8.

[26] Note that the regressions use correlation estimates as the dependent variable in the presence of overlapping observations with persistent regressors. Though the standard errors of the coefficient estimates are adjusted for this serial dependence, the R^2s will also have a bias (e.g., see Boudoukh, Richardson and Whitelaw (2008)). Because there are effectively many fewer observations due to the overlap, the R^2s will need more than the standard adjustment for additional regressors. As one way to capture this bias, we simulate multivariate normal series with persistence to match the actual regressors and estimate regressions of rolling correlations on these regressors in a setting where the true R^2 is zero. The adjusted R^2, which is the estimated R^2 less the average simulated spurious R^2, is provided in Table 6 immediately below the standard R^2 calculation.

Interpreting the results in Figure 2 and Table 6 is potentially difficult due to the small number of non-overlapping observations. However, by using information in the cross-section about the correlation between stocks and interest rates, we gain additional observations. To this end, we run a pooled time-series regression of the 36-month rolling correlation between the returns on individual stocks and government bonds on leverage and asset durations and estimate the time fixed effect. The gray line in Figure 3 plots the time-series of this time fixed effect and corresponding confidence bands. This fixed effect can be viewed as the average correlation between the returns on individual equities and government bonds, adjusted for asset returns and leverage. The black line in Figure 3 provides estimates of the time fixed effect from the regression without any controls.

There are some key takeaways from Figure 3. First, the average correlation with the controls for leverage and asset duration shows much less variation over time than the average correlation without these controls, indicating that leverage and asset duration are key determinants of the correlation between stock returns and interest rates. Second, there is still a swing from positive to negative in the correlation between the returns on equities and government bonds, even with the controls included, suggesting that other factors such as liquidity are also at play. Finally, note that the correlation estimates are in general closer to zero than those in Figure 2. This reduction in magnitude may be due to a reduction in estimation error when using the full cross-section. Alternatively, correlations at the aggregate level may be larger in magnitude because of a reduction in idiosyncratic volatility.

B. Corporate Bond Index Returns and Government Bond Returns

Overall, the results above indicate that leverage is an important variable for explaining time variation in the correlation between the returns on government bonds and equity indexes. Equation (14) also implies that both leverage and priority should be important for explaining the correlation between the returns on government bonds and corporate bond indexes.

In order to investigate this conjecture, we construct two corporate bond portfolios from a subset of the firms used in our prior analyses. The first portfolio is made up of the highest priority fixed-rate bonds of the firms, while the second portfolio is made up of the lowest priority fixed-rate bonds of the same firms. In each case we exclude bonds with embedded options. We focus on firms with high-yield debt in the post-1992 period to ensure that there are at least 30 bonds in each portfolio. The two portfolios have the same number of bonds drawn from the same firms, and portfolio returns are equal-weighted averages of the returns on the bonds in the portfolios.

Figure 4 graphs the number of bonds in the portfolios and their average ratings through time.[27] Starting in the late 1990s, there is a large increase in the number of bonds within each portfolio, presumably producing a better-diversified collection of securities. Through the early 2000s, the average credit ratings of the bonds are relatively high with only a small differential between the average ratings of the two portfolios. After measuring the likelihood of a firm's default, the ratings agencies generally determine the cross-section of ratings on bonds within a firm based on priority, anchored by the firm rating. Therefore, the increasing spread of the ratings between our high and low priority bond portfolios post 2002 suggests the firms have an increasing cross-section of bonds with different priorities.

Figure 5 plots correlations similar to those of Figure 2, but now for the two portfolios of corporate bonds. By construction, the portfolios have bonds from firms with the same average leverage, but the portfolios have bonds that differ in their priority. Assuming that asset duration is near zero, our theory predicts that duration declines with priority and moves from positive to negative as we move from high priority debt to equity. In addition, as with equity, the corporate bond correlations should move with the inverse of leverage.

Figure 5 confirms these predictions. First, the correlation of the senior bond portfolio is always higher than that of the junior bond portfolio. Second, the impact of leverage is also visible. Post 2000, the level of inverse leverage closely tracks the corporate bond-government bond correlation, especially so for the junior bond portfolio. As leverage increases, i.e., as the ratio of market value of assets to book debt falls, the correlation decreases. Indeed, as a result of the financial crisis of 2007-2009, leverage is at its highest point in the sample and the junior bond portfolio has its lowest–in fact, negative–correlation with government bonds. Finally, when we adjust the bond portfolios for their sensitivity to the return on the underlying assets, the results still hold.

[27] For Figure 4, higher ratings are associated with lower numerical values, i.e., AAA=1, AA+=2, etc., in contrast to the ratings variable used in Table 4 and described in footnote 26, which uses the reverse scale.

Table 7 provides results of the regression counterpart to Figure 5. The two main findings are that the correlation between corporate bonds and government bonds is decreasing in leverage, and that this correlation is higher for senior than for junior debt. For example, the coefficients on leverage (BDMA) in Column 1 are -0.16 and -0.29 on senior and junior debt, respectively, with *t*-statistics well above 3. In other words, a one-standard deviation increase in the average leverage of the portfolio leads to 16% and 29% drops in the correlations for senior and junior debt, respectively. As the theory suggests, higher leverage leads to lower duration for all corporate bonds and the magnitude is greater for bonds of lower priority. Because we have de-meaned the regressors, the constants in Column 1 represent the average correlation between the corporate bond returns and the government bond returns over the sample period. Again consistent with the theory, the senior bond portfolio has a higher average correlation than the junior bond portfolio, 0.76 versus 0.57. The results are robust to the inclusion of controls for asset volatility, liquidity and macroeconomic factors in Columns 2-4 and the adjustment for the sensitivity of the bonds to asset returns in Columns 5-8.

These results for the durations of corporate bonds of different priority are potentially important for constructing a suitable measure of the default premium. It is standard in the literature (e.g., Fama and French (1989, 1993)) to measure the default premium as the yield or return spread between high-yield corporate debt and AAA-rated corporate debt, in order to isolate default risk from interest rate risk. However, these different classes of debt contain securities with different priority and thus different durations and different interest rate risk premiums, which vary with the time variation in leverage. Therefore, the default premium may, in fact, be comingling the two risk components with changing weights through time. We address this issue in Section VI.

VI. Implications for Factor-Pricing Models

In this section, we apply our insights on the effects of capital structure priority to reinterpret some well-known empirical results on stock and bond factor-pricing models. In particular, we shed new light on (i) corporate bond betas, (ii) traditional term premium and default premium risk factors, and (iii) joint models of time-varying expected returns on stocks and bonds.

A. Corporate Bond Betas

There is an extensive literature in finance that tries to measure the betas of corporate bonds. Using a standard market model motivated by the CAPM, Alexander (1980) and Chang and Huang (1990), among others, run regressions of excess corporate bond returns on aggregate equity market returns and find the betas to be lower than their credit risk would suggest. Once one recognizes the priority structure of corporate securities, it is not surprising that the typical CAPM regression produces counter-intuitive results. Rewriting the aggregate equity market return $R^{M}_{t,t+1}$ in terms of the returns on the corresponding underlying assets $R^{V_M}_{t,t+1}$ and debt $R^{D_M}_{t,t+1}$,

$$R^{B_i}_{t,t+1} - R^{F}_{t} = \alpha + \beta\left(R^{M}_{t,t+1} - R^{F}_{t}\right) + \varepsilon_{t,t+1}$$

$$= \alpha + \beta\left(\left(R^{V_M}_{t,t+1} - R^{F}_{t}\right) + \frac{D_{Mt}}{E_{Mt}}\left(R^{V_M}_{t,t+1} - R^{D_M}_{t,t+1}\right)\right) + \varepsilon_{t,t+1}\,, \qquad (15)$$

where $\frac{D_{Mt}}{E_{Mt}}$ is the debt-equity ratio of the market. The corporate bond beta with respect to the equity market return reflects two components, $\text{cov}(R^{B_i}_{t,t+1}, R^{V_M}_{t,t+1})$ and $\text{cov}(R^{B_i}_{t,t+1}, \frac{D_{Mt}}{E_{Mt}}(R^{V_M}_{t,t+1} - R^{D_M}_{t,t+1}))$. The first term is the covariance of a firm's bond return with the aggregate return on the assets of all firms. This is the covariance that determines the required bond return according to the CAPM. If a firm's debt value does not vary much with the aggregate economy, then its true CAPM beta would be close to zero. However, this is not necessarily true of the beta in equation (15). To the extent that aggregate corporate debt in the economy moves with interest rates, the estimated beta from equation (15) for relatively safe debt will tend to be negative since

$$\text{cov}\left(R^{B_i}_{t,t+1}, \frac{D_{Mt}}{E_{Mt}}\left(R^{V_M}_{t,t+1} - R^{D_M}_{t,t+1}\right)\right) < 0\,.$$

Alternatively, if a firm's debt value does vary greatly with the aggregate economy, yet does not vary much with interest rates (due to the low priority of its claim), then the estimated beta from equation (15) will be positive but scaled down by $1 + \frac{D_{Mt}}{E_{Mt}} = \frac{V_{Mt}}{E_{Mt}}$. Equation (15) also makes obvious the fact that these relations are time-varying if for no other reason than through their dependence on $\frac{V_{Mt}}{E_{Mt}}$, which varies over time.

Table 8 reports results for the traditional CAPM regression of corporate bond returns on the aggregate equity market return. We perform this regression for portfolios of bonds with different maturities, different capital structure priorities, and different levels of credit risk. Consistent with existing evidence, all the coefficients for investment grade bonds are small. This result has been interpreted as evidence that investment grade corporate bonds should have low risk premiums. The coefficients on high-yield bonds are higher, but arguably lower than one might expect given the close relation between the values of low priority, risky debt and equity.

However, equation (15) shows that the use of the aggregate equity return in the CAPM regression yields understated beta estimates given that equity claims are long the assets and short fixed rate debt. We modify regression equation (15) in two different ways. First, we decompose the aggregate equity return into the asset return and a remainder term, $R^{M}_{t,t+1} - R^{V_M}_{t,t+1}$, which equals $\frac{D_{Mt}}{V_{Mt}}\left(R^{M}_{t,t+1} - R^{D_M}_{t,t+1}\right)$ and thus captures the short debt component. Second, we simply replace the aggregate equity return with the aggregate asset return.

The results of the first alternative specification are striking. The coefficient on the asset return is considerably higher, while the coefficient on the remainder term is negative. For example, consider the shortest maturity, high priority, investment grade portfolio. While its coefficient on the equity market return is only 0.06, the coefficient on the aggregate asset return is 0.31 and the coefficient on the remainder term is -0.52. Thus, the low equity market beta of corporate bonds is not because the asset beta is low but because this equity market beta is depressed by equity's implicit short position in debt.

To see this more directly, consider the second alternative specification in which we simply regress the bond portfolio return on the aggregate asset return. The results are less dramatic but still point in the same direction. For all bond portfolios, irrespective of maturity, priority, or credit risk, the beta is substantially higher using asset returns than equity returns. For example, again consider the shortest maturity, high priority, investment grade portfolio. The beta coefficient almost doubles from 0.06 to 0.11, and this difference is highly statistically significant, as indicated in the column labeled *Diff*, which gives the standard error of the difference. Corporate bonds have significantly more market risk than existing studies suggest.

B. Term and Default Risk Factors

In order to decompose excess returns on corporate securities into components due to interest rate risk and default risk, researchers have estimated versions of the following popular Fama and French (1993) regression framework (see, for example, Elton, Gruber, Agrawal, and Mann (2001), Gebhardt, Hvidkjaer, and Swaminathan (2005), and Bao, Pan, and Wang (2011)):

$$R_{t,t+1}^{i} - R_t^F = \alpha + \beta_1\left(R_{t,t+1}^{LTG} - R_t^F\right) + \beta_2\left(R_{t,t+1}^{CORP} - R_{t,t+1}^{LTG}\right) + \varepsilon_{t,t+1}\,, \tag{16}$$

where $R_{t,t+1}^{i}$ is a corporate security return, $R_{t,t+1}^{LTG} - R_t^F$, or TERM, is the "term factor," the excess return on a long-term government bond, and $R_{t,t+1}^{CORP} - R_{t,t+1}^{LTG}$, or DEF, is the "default factor," the return on corporate debt minus the return on a long-term government bond. However, our theory shows that this approach may be misleading because, in general, $R_{t,t+1}^{CORP}$ includes debt of low priorities, which reduces its duration. If the duration of $R_{t,t+1}^{CORP}$ is lower than that of $R_{t,t+1}^{LTG}$, then the difference is subject to both interest rate risk and default risk. Since this mis-measured default factor loads negatively on the term factor, the coefficient on the term factor needs to be higher in order to offset this effect, and the apparent effect of interest rate risk will be overstated.

To better understand the potential problem with the specification in equation (16), we run two sets of regressions of returns on portfolios of bonds and equities sorted by their firm ratings against the five Fama and French (1993) factors, i.e., the three equity factors, RMRF, SMB, and HML, and the two bond factors, TERM and DEF. The sets of regressions differ by their definition of DEF, one using the Fama and French (1993) definition in equation (16) above, and the other recognizing that the duration of corporate bonds differs from that of government bonds. In particular, let DEF1 denote the return spread between aggregate corporate bonds and long-term government bonds as in Fama and French (1993), and let DEF2 denote the difference between returns on aggregate corporate bonds and a five-year government bond, to account for the lower duration of corporate bonds. The sample period is 1990-2012, when data on high-yield bond index returns are available.

Table 9, Panels A and B report coefficient estimates for equation (16) for the six issuer-level ratings portfolios, using the two alternative default factors, DEF1 and DEF2, and Panel C provides formal tests of their differences. As we conjectured above, for both equity and bond portfolio returns, the loadings on TERM tend to be larger in Panel A than in Panel B. In fact, for the bond portfolios the differences are always positive and economically and statistically significant. For example, the estimated coefficient on TERM in Panel A for the B-rated bonds is 1.00, versus 0.03 in Panel B. Thus, it is clear that the mis-specified regression vastly overstates the effect of interest rate risk on return premiums for high-yield bonds.

Turning to the coefficients on the default factors, a curious feature of both Panels A and B is the large positive coefficient of AAA bond returns on both DEF1 and DEF2 despite the well-known low probability of default of AAA bonds. A likely explanation for this phenomenon is a missing liquidity factor on which all corporate bonds load positively. This missing liquidity factor would also explain the decline in the coefficient when we replace DEF1 with DEF2, if Treasury bonds load negatively on this factor, as might be expected in flights to quality. In any case, these results suggest that the typical approach, inspired by Fama and French (1993), also overstates the degree of default risk, particularly among investment grade bonds.

C. Time-Variation in Expected Returns

In his AFA presidential address, Cochrane (2011) states that discount rate variation, i.e., the structure of expected returns on different asset classes, is a central issue in asset pricing research. He reviews a wide range of models from finance and macroeconomics, including those that incorporate market frictions and behavioral phenomena. However, he does not discuss the importance of leverage and the structural link between stocks and bonds described in this paper.

Cochrane (2011) frames his discussion with the following model for expected stock and bond returns:

$$R^E_{t,t+1} = \alpha_E + \beta_{1E} e_t + \beta_{2E} b_t + \beta_{ZE} z_t + \varepsilon^E_{t,t+1} \tag{17}$$

$$R^B_{t,t+1} = \alpha_B + \beta_{1B} e_t + \beta_{2B} b_t + \beta_{ZB} z_t + \varepsilon^B_{t,t+1} \,,$$

where $R^E_{t,t+1}$ is the return on stocks, $R^B_{t,t+1}$ is the return on bonds, e_t are equity factors such as dividend yield, b_t are bond factors such as the term spread, and z_t are additional predictor variables. He suggests that the finance field needs to better understand the coefficients β_{2E} and β_{1B}.

There has been a growing literature in finance over the last quarter century organized around identifying these coefficients. Examples of this literature include Keim and Stambaugh (1986), Campbell (1987), Fama and Bliss (1987), Fama and French (1989), Ferson and Harvey (1991), Ilmanen (1995), Boudoukh, Richardson, and Whitelaw (1997), Campbell (2000), Harvey (2001), Lettau and Ludvigson (2001), Cochrane and Piazzesi (2005), Guo and Whitelaw (2006), Ang and Bekaert (2007), Boudoukh, Michaely, Richardson, and Roberts (2007), Bollerslev, Tauchen, and Zhou (2009) and Ludvigson and Ng (2009), among others. While these papers identify likely predictor variables, Cochrane (2011) points out that there has not been much progress in understanding the joint determinants of time-varying expected returns on stocks and bonds, as would be implied by the existence of a single stochastic discount factor.

It is clear from Cochrane's discussion and much of the aforementioned literature that researchers consider returns on a portfolio of firm equity and returns on a portfolio of firm assets as interchangeable. However, this treatment ignores the levered nature of equity returns, namely that stock returns are long asset returns and short bond returns, $R^E_{t,t+1} = \frac{A_t}{E_t} R^A_{t,t+1} - \frac{D_t}{E_t} R^B_{t,t+1}$. With this decomposition in mind, we augment the regression system (17) with a third equation for asset returns:

$$R^A_{t,t+1} = \alpha_A + \beta_{1A} e_t + \beta_{2A} b_t + \beta_{ZA} z_t + \varepsilon^A_{t,t+1} \,. \quad (18)$$

Table 10 presents results from the estimation of regression system (17) and (18), using the following three predictors: the dividend yield of Fama and French (1988), the term spread, i.e., the difference between the ten-year CMT yield and the three-month T-bill yield, and the default spread of Keim and Stambaugh (1986), i.e., the yield spread between high-yield corporate bonds and T-bills. The economic magnitudes of the coefficients in Table 10 highlight the intuition outlined above, although some of the coefficient estimates are statistically insignificant due to our relatively short sample period 1990-2012. The predictability of the dividend yield is strong for equity returns. This predictability stems largely from the predictability of the dividend yield for asset returns. The dividend yield predicts bond returns only weakly. Similarly, the negative coefficient on the term spread for equity returns comes mainly from asset returns. On the other hand, the estimated negative coefficient on the default spread for equity returns is due, at least in part, to the short position in bond returns. Corporate bond returns load positively on this spread, which is not surprising. The analysis above shows that an understanding of the discount factors for stocks and bonds, i.e., the coefficients in equations (17) and (18), is only possible when one recognizes that equity is a long position in the assets of the firm with a short position in fixed-rate debt.

There remains the question of how to choose and interpret the predictive variables in the first place. Two seminal papers in the area, Keim and Stambaugh (1986) and Fama and French (1993), use different measures of the default premium and report different results. The Keim-Stambaugh measure, DEF(FF), is the yield spread between high-yield corporate debt and T-bills, which we use in Table 10. The Fama-French measure, DEF(FF), is the yield spread between high-yield corporate debt and AAA-rated corporate debt, presumably designed to isolate default risk from interest rate risk. However, as pointed out in Section V.B, changes in yields of low priority corporate debt have little relation to changes in interest rates. Therefore, DEF(FF) may in fact be comingling the two risk components.

Table 11 reports results of the predictive regressions for equity returns using these two different default premium measures and shows that there is indeed a significant difference in the economic magnitudes of the coefficients. In the regression using DEF(FF), the coefficient estimates are -0.07 and -0.20 for the yield spread and default spread, respectively. However, in the regression using DEF(FF), we find that both estimates are further away from zero, taking on the values -0.29 and -0.27 for the yield spread and default spread, respectively. Thus, this latter regression erroneously suggests larger term and default risk premiums than actually exist. While the individual coefficient estimates are not statistically significant due to our relatively short sample, the differences are both economically and statistically significant (at least for default spread). These differences illustrate the need to account for the structural relation between corporate security returns when analyzing time variation in expected equity and bond returns, and they reinforce our broader conclusions about the importance of capital structure effects in asset prices.

VII. Concluding Remarks

The relation between security returns and interest rates is central to finance. Previous research has, for the most part, ignored financial leverage and the priority structure of corporate capital structures in analyzing this relation. The first message of this paper is that capital structure priority matters for determining the interest rate sensitivity of corporate securities. In particular, we show theoretically and confirm empirically that lower priority securities in the capital structure, such as subordinated debt and equity, have low or even negative durations. This result obtains because the lower priority securities are effectively short higher priority fixed rate debt.

Using these insights, we challenge existing results in the literature on time-varying correlations between returns on the aggregate stock, corporate bond and government bond markets, and factor-pricing models for stocks and bonds. First, leverage and priority are key determinants of the time-variation in the correlation between corporate security returns and interest rates that have been largely ignored in the existing literature. For example, higher leverage induces a lower correlation between equity and government bond returns, and lower priority reduces the correlation between corporate and government bond returns. Second, traditional market model regressions materially understate corporate bond betas. Finally, existing measures of corporate bond default factors lead to an overstatement of both default and interest rate risk in corporate security returns.

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Appendix

Derivations of Durations

The modified duration of the firm's assets is

$$\mathrm{Dur}(V) \equiv -\frac{\mathrm{cov}\left(\frac{dV_t}{V_t}, dr_t\right)}{\mathrm{var}(dr_t)} = -\frac{\rho\sigma}{v}.$$

For the senior bond, modified duration is

$$\mathrm{Dur}(D_S) \equiv -\frac{\mathrm{cov}\left(\frac{dD_S}{D_S}, dr\right)}{\mathrm{var}(dr)} = -\frac{\mathrm{cov}\left(\frac{\partial D_S}{\partial r}\frac{1}{D_S} v dW + \frac{\partial D_S}{\partial V}\frac{V}{D_S}\sigma dZ, v dW\right)}{\mathrm{var}(dr)}$$

$$= -\frac{\partial D_S}{\partial r}\frac{1}{D_S} - \frac{\partial D_S}{\partial V}\frac{V}{D_S}\frac{\rho\sigma}{v},$$

where $\frac{dD_S}{D_S}$ is obtained from Ito's formula. Similarly, the modified durations of the junior bond and equity are

$$\mathrm{Dur}(D_J) = -\frac{\partial D_S}{\partial r}\frac{1}{D_S} - \frac{\partial D_J}{\partial V}\frac{V}{D_J}\frac{\rho\sigma}{v}$$

$$\mathrm{Dur}(E) = -\frac{\partial E}{\partial r}\frac{1}{E} - \frac{\partial E}{\partial V}\frac{V}{E}\frac{\rho\sigma}{v}.$$

Extending the Model with Default Prior to Maturity

With zero-coupon debt there is no reason for equity holders to default prior to the maturity of the debt unless forced to do so. However, if equity holders need to inject additional funds in order to make debt payments, then endogenous optimal default can occur prior to maturity for sufficiently low asset values. In the second panel of Figure 1 (when asset duration is zero), the duration of junior debt becomes negative when firm value reaches approximately 41, with a face value of zero-coupon debt of 50. At this point, the debt-equity ratio is close to 4, and the yield on the junior debt is 13% relative to a risk-free rate of 5%, i.e., the firm is arguably close to financial distress. The question is whether the possibility of early default changes the durations of debt and equity in these states.

To answer this question, we turn to the model in Black and Cox (1976).[28] Rather than introducing debt payments prior to maturity into the base case model, this model maintains the zero-coupon debt assumption and instead specifies an exogenous default boundary as a fraction, $f < 1$, of the present value of the outstanding debt. When asset value hits this boundary, the firm defaults and the value of the assets goes to the debtholders following absolute priority. To gain intuition, consider the case where f is sufficiently high and there is enough junior debt relative to senior debt that the senior debt will be riskless. Following Black and Cox (1976), the interest rate is set to be constant.

Using the same asset value process and capital structure as in Section II.A, assume that the firm defaults when the asset value first falls to $f(K_S + K_J)e^{-rt}$, where t is the remaining maturity of the bonds, i.e., the default boundary is set at a constant fraction of the present value of the face amount of the debt. Assume further that $f\left(K_S + K_J\right) > K_S$, which implies that there is always enough asset value at default to pay off the senior debtholders and this debt is risk-free. By equation (5) in Black and Cox (1976), the total value of the debt is[29]

$$D_S + D_J = \left(K_S + K_J\right)e^{-r\tau}[N(z_1) - y^{-1}N(z_2)] + V[N(z_3) + yN(z_4)]$$

$$y = \frac{f\left(K_S + K_J\right)e^{-r\tau}}{V}$$

$$z_1 = \frac{\ln\left({V}/{(K_S + K_J)}\right) + (r - 0.5\sigma^2)\tau}{\sigma\sqrt{\tau}}$$

$$z_2 = \frac{\ln\left({V}/{(K_S + K_J)}\right) + 2\ln(y) + (r - 0.5\sigma^2)\tau}{\sigma\sqrt{\tau}}$$

$$z_3 = \frac{-\ln\left({V}/{(K_S + K_J)}\right) - (r - 0.5\sigma^2)\tau}{\sigma\sqrt{\tau}}$$

[28] Longstaff and Schwartz (1995) also examine the effect of early default on the value of corporate debt. However, their framework is not well-suited to examining the effects on equity value because their model does not impose the constraint that the sum of the values of the claims on the firm, i.e., debt and equity, equals the value of the firm's assets.

[29] There is a typographical error in equation (5) in the published version of the paper. The second to last component should include the term $y^{\theta+\eta}$ not $y^{\theta-\eta}$.

$$z_4 = \frac{\ln\left(V/(K_S + K_J)\right) + 2\ln(y) + (r + 0.5\sigma^2)\tau}{\sigma\sqrt{\tau}} .$$

The value of the junior debt is the total value of the debt less the value of the risk-free senior debt:

$$D_J = (K_S + K_J)e^{-r\tau}[1 - N(-z_1)] + VN(z_3) - K_S e^{-r\tau} - \frac{V}{f}N(z_2) + f(K_S + K_J)e^{-r\tau}N(z_4) .$$

Therefore, the value of the junior debt is (see the Online Appendix for the details)

$$\begin{aligned} D_J &= K_J e^{-r\tau} - \left[(K_S + K_J)e^{-r\tau}N(-z_1) - VN(z_3)\right] + \left[f(K_S + K_J)e^{-r\tau}N(z_4) - \frac{V}{f}N(z_2)\right] \\ &= K_J e^{-r\tau} - P(V, K_S + K_J, \tau, r, \sigma) + P\left(\frac{V}{f}, f(K_S + K_J), \tau, r, \sigma\right), \end{aligned}$$

where $P(\cdot)$ is the Black-Scholes put value.

This value of junior debt is equivalent to the value in equation (2) with two adjustments. The put option associated with the senior debt has been eliminated because that debt is riskless, and the value is increased by an amount equal to a put option on an inflated firm value and deflated exercise price because early default increases debt value. However, for reasonable values of f, the value of this latter term is small relative to the other put option term, and thus it has a correspondingly small effect on duration. For example, for $f = 0.75$, which implies a recovery rate of 50% on the junior debt in the event of default, the duration of this junior debt becomes negative for a firm value just less than 40, which is similar to the result in Figure 1. Of course, in a world of early default, it makes no sense to extend the figure to firm values below which default occurs, which is less than 30 for $f = 0.75$ in Figure 1, but this concern does not arise in the context of the empirical analysis. It is an empirical question as to whether the firms in our sample survive to the point at which junior debt duration goes negative or whether asset duration is sufficiently negative such that this switch occurs for higher firm values as in the first panel of Figure 1.

Table 1. Summary Statistics on Debt Priority and Leverage

Distributions of debt priority and leverage over the period 1980-2012 for non-financial firms with available asset return data. The first two rows of Panel A describe the distribution of the number of debt priority levels in the capital structure. The remainder of Panel A reports the types of debt within these priority levels, as a fraction of total assets. For each priority group, we report average time-to-maturity and the fraction of high and low priority bonds, out of total assets, that are fixed and floating rate. For firms with an odd number of priority levels, *2n-1*, the bonds in the higher *n* priority levels are defined as high priority and the bonds in the lower *n-1* priority levels are defined as low priority. For firms with an even number of priority levels, *2n*, the bonds in the higher *n* priority levels are defined as high priority and the bonds in the lower *n* priority levels as low priority. In Panel B, we report the average and the 25th, 50th, and 75th percentiles of market assets (MA), market debt to market equity (MD/ME), and market assets to book debt (MA/BD).

Panel A: Debt Priority Distribution

		# Priority Levels	1	2	3	4 or more	Total
		# Observations	184,348	58,605	20,495	16,038	279,486
Priority	High	Fixed	29.4%	18.7%	24.1%	22.4%	
		Floating	0.7%	0.7%	1.0%	1.5%	
		Avg. Maturity	5.81	5.59	5.80	7.08	
	Low	Fixed		17.9%	8.8%	13.5%	
		Floating		0.6%	0.2%	0.6%	
		Avg. Maturity		6.13	6.27	6.71	
		Loan	15.4%	14.0%	14.5%	15.9%	

Panel B: Leverage Distribution

	Avg.	25th Pct.	50th Pct.	75th Pct.
MA	8,267	755	2,062	5,998
MD/ME	0.93	0.21	0.45	0.95
MA/BD	5.85	1.87	2.98	5.50

Table 2. Simple Duration Estimates for Corporate Securities Grouped by Firm Leverage

Duration is estimated as the coefficient β from the following pooled, ordinary least squares (OLS) regression, over the period 1980-2012 for five subsamples of firms grouped by leverage:

$$R_t^i = \alpha + \beta(-\Delta i_t) + \varepsilon_t.$$

The dependent variable, R_t^i, is alternately the monthly return on senior debt, junior debt, equity, and assets, and Δi_t is the change in the five-year CMT yield. For each firm-month, the senior and junior debt returns are the value-weighted averages of the returns on the firm's high and low priority bonds, respectively. The high and low priority bonds are defined as in Table 1. Firms are sorted each year into a zero leverage group and four other groups of equal size based on leverage, defined as the ratio of market assets to book debt from the previous year. To be included in one of the four groups of levered firms, firms are required to have both high and low priority bonds with at least three years to maturity and value greater than 10% of the value of firm's total debt. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. Numbers in parentheses are White robust standard errors.

Leverage Group		Senior	Junior	Equity	Asset
Zero	$-\Delta i$			-1.74***	-1.74***
				(0.15)	(0.15)
	R^2 in %			0.0	0.0
Low	$-\Delta i$	2.90***	2.22***	-1.70***	-1.20***
		(0.12)	(0.19)	(0.39)	(0.35)
	R^2 in %	7.8	1.8	0.0	0.0
2	$-\Delta i$	2.49***	2.13***	-0.91***	-0.33
		(0.10)	(0.14)	(0.33)	(0.25)
	R^2 in %	8.8	3.3	0.0	0.0
3	$-\Delta i$	2.13***	1.48***	-1.63***	-0.48**
		(0.10)	(0.13)	(0.35)	(0.22)
	R^2 in %	6.4	3.0	0.0	0.1
High	$-\Delta i$	0.84***	0.60**	-2.10***	-0.59**
		(0.17)	(0.24)	(0.55)	(0.23)
	R^2 in %	0.2	0.0	0.1	0.0

Table 3. Within-Firm Differences in Durations of High and Low Priority Securities

Coefficient estimates, their standard errors, and R^2s from the pooled regression

$$R_{t+1}^{m} - R_{t+1}^{n} = \alpha + \beta(-\Delta i_{t+1}) + \gamma(\tau_t^m - \tau_t^n)(-\Delta i_{t+1}) + \epsilon_{t+1},$$

where $R_{t+1}^{m} - R_{t+1}^{n}$ is the difference in monthly returns between two securities issued by the same firm, with security *m* being lower priority than security *n*, and $\tau_t^m - \tau_t^n$ is the difference in the average cash flow life of the two securities. When R_{t+1}^{m} is an equity return, R_{t+1}^{n} represents the return on all of the fixed-rate bonds of the firm and τ_t^m is set to zero. When security *m* is a bond, bond *n* is required to be of the same type as *m* in terms of callability, convertibility, and coupon type (floating versus fixed). The sample period is 1980-2012. To be included in the sample, bonds are required to have more than $100 million outstanding and time to maturity longer than 3 years. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. Standard errors, in parentheses, are clustered by firm and time.

	Bond				Equity	
$-\Delta i$	-0.295***	-0.241***	-0.283***	-0.239***	-1.536***	-1.452***
	(0.084)	(0.082)	(0.085)	(0.082)	(0.220)	(0.256)
$(\tau^m - \tau^n)(-\Delta i)$		0.125***		0.129***		0.009
		(0.020)		(0.039)		(0.028)
Const	0.001***	0.001***	0.001***	0.001***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R^2 in %	0.1	0.3	0.2	0.3	0.3	0.3
N	480,072	480,072	480,072	480,072	1,129,278	1,129,277
Bond Type FE	No	No	Yes	Yes	No	No

Table 4. Estimates of Duration as a Function of Leverage and Priority

Coefficient estimates, their standard errors, and R^2s for various versions of the regression model in the following equation.

$$R_{t+1} = \alpha + \beta_t \tau_t (-\Delta i_{t+1}) + \theta_t RA_{t+1} + FE_t + \epsilon_{t+1}$$
$$\beta_t = \beta_0 + \beta_1 L_t + \beta_2 P_t + \beta_3 L_t P_t + \beta_4 Z_t + FE_t$$
$$\theta_{it} = \theta_0 + \theta_1 L_t + \theta_2 P_t .$$

For bonds, in Panel A, R_t is the bond return; τ_t is the average cash flow life of the bond; L_t is the leverage of the firm, defined as log of one plus book debt divided by market assets; P_t is the priority of the bond, defined as one minus the fraction of the face value of bonds that are senior to that bond; Z_t is a set of dummy variables for callable, convertible, putable, floating rate and asset-backed bonds; RA_t is the firm's asset return; FE_t are ratings fixed effects; and Δi_t is the change in the five-year CMT yield. To be included in the sample, bonds are required to have face value greater than $100 million and time to maturity greater than three years. For equities, in Panel B, we drop average cash flow life, the priority variable, and the dummy variables from the specification. We report pooled OLS estimation results with standard errors clustered by firm and time in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. The sample period is 1980-2012.

Panel A: Duration of Bonds

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\tau(-\Delta i)$	0.210***	0.162***	0.197***	0.321***	0.027*	0.347***	0.024
	(0.025)	(0.019)	(0.039)	(0.017)	(0.016)	(0.016)	(0.016)
$L \cdot \tau(-\Delta i)$	-0.052**	-0.061***	0.002				
	(0.021)	(0.016)	(0.070)				
$P \cdot \tau(-\Delta i)$	0.109***	0.098***	0.099***				
	(0.025)	(0.019)	(0.023)				
$L \cdot P \cdot \tau(-\Delta i)$	0.041***	0.028**	0.043**				
	(0.015)	(0.014)	(0.022)				
RA		0.536***	0.534***	0.235***	0.235***		
		(0.021)	(0.021)	(0.004)	(0.004)		
$L \cdot RA$		0.118***	0.117***				
		(0.007)	(0.007)				
$P \cdot RA$		-0.188***	-0.188***				
		(0.022)	(0.022)				
$Rating \cdot \tau(-\Delta i)$					0.015***		0.016***
					(0.001)		(0.001)
R^{Equity}						0.125***	0.126***
						(0.003)	(0.003)
Const	0.007***	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Rating FE	N	N	Y	Y	Y	Y	Y
Rating FE $\cdot \tau\Delta i$	N	N	Y	Y	N	Y	N
R^2 in %	5.5	25.4	25.4	20.6	20.4	17.3	17.1
N	644,329	643,765	643,765	652,549	652,549	652,611	652,611

Panel B: Duration of Equity

	(1)	(2)
$-\Delta i$	0.151	-0.669***
	(0.258)	(0.143)
$L(-\Delta i)$	-0.000	-0.200**
	(0.159)	(0.090)
RA		1.644***
		(0.020)
$L(RA)$		0.219***
		(0.011)
Const	0.010***	-0.001***
	(0.000)	(0.000)
R^2 in %	0.0	80.5
N	184,637	183,951

Table 5. Duration Estimates for Corporate Securities Grouped by Asset Duration

Coefficient estimates, their standard errors, and R^2s for versions of the following regression model for terciles of firms sorted on asset duration:

$$R_{t+1} = \alpha + \beta_t \tau_t(\Delta i_{t+1}) + \epsilon_{t+1}$$
$$\beta_t = \beta_0 + \beta_1 L_t + \beta_2 P_t + \beta_3 L_t P_t + \beta_4 Z_t \,.$$

The regressors are as described in Table 4. Asset duration is estimated from regressions of asset returns on the negative of five-year CMT yield changes over the previous 36 months. We exclude financials. We report pooled OLS estimation results with standard errors clustered by firm and time in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. The sample period is 1980-2012.

Panel A: Duration of Bonds

	Asset Duration Tercile		
	Low	Mid	High
$\tau(-\Delta i)$	-0.182***	0.133**	0.252***
	(0.068)	(0.052)	(0.035)
$L \cdot \tau(-\Delta i)$	-0.327***	-0.099**	0.061**
	(0.047)	(0.041)	(0.026)
$P \cdot \tau(-\Delta i)$	0.407***	0.157***	0.039
	(0.072)	(0.054)	(0.037)
$L \cdot P \cdot \tau(-\Delta i)$	0.261***	0.073*	-0.063**
	(0.050)	(0.042)	(0.027)
Const	0.007***	0.007***	0.007***
	(0.000)	(0.000)	(0.000)
R^2 in %	2.2	5.6	7.1
N	163,976	175,578	178,344

Panel B: Duration of Equity

	Asset Duration Tercile		
	Low	Mid	High
$-\Delta i$	-8.308***	-0.861	6.372***
	(0.633)	(0.537)	(0.621)
$L(-\Delta i)$	-2.467***	-0.587*	1.029***
	(0.392)	(0.355)	(0.396)
Const	0.013***	0.012***	0.012***
	(0.001)	(0.001)	(0.001)
R^2 in %	1.2	0.0	1.4
N	41,605	31,877	33,846

Table 6. Regressions of Correlations between Equity Returns and Government Bond Returns

The dependent variable in columns 1-4 is the correlation between monthly equity and five-year CMT returns, and the dependent variable in columns 5-8 is the correlation between monthly asset-neutral equity and five-year CMT returns, each estimated over the previous 36 months. The equity return is the value-weighted average of stock returns on non-financial firms in our sample. The asset-neutral equity return is the value-weighted average of individual asset-neutral equity returns on the non-financial firms, estimated as $R^e_{p,t+1} \equiv \Sigma_i w_{i,t}\left(R_{i,t+1} - \theta_{i,t} RA_{i,t+1}\right)$ based on the regressions in Table 4. BDMA is aggregate book debt over the market value of assets of the firms in our sample. Asset volatility controls include the ratio of the aggregate asset volatility of our sample firms to the volatility of changes in 5-year CMT yields, estimated from monthly returns and yield changes over the previous 36 months. Liquidity controls include VIX; stock market liquidity, measured as the market value-weighted average proportion of zero daily stock returns across firms, over the month; bond market liquidity, measured as a monthly average of quoted bid-ask spreads on off-the-run bonds across maturities; and the interaction between these stock and bond market liquidity measures. Macro controls include the dividend yield of Fama and French (1988); the yield spread between BBB and AAA corporate bonds; the term spread between ten-year and one-year CMT rates; and the three-month T-bill rate. We also report the adjusted R^2, which is the estimated R^2 less the average spurious R^2. The spurious R^2 is calculated by simulating multivariate normal series with persistence to match the actual regressors and regressing correlation estimates on these regressors in a setting where the true R^2 is zero. All explanatory variables, including interaction terms, are standardized using sample means and standard deviations. The sample period is 1986-2012. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. The numbers in parentheses are Newey-West standard errors.

	Equity and Treasury Bonds				Asset-Neutral Equity and Treasury Bonds			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Const	-0.001	-0.001	-0.001	-0.001	-0.341***	-0.341***	-0.341***	-0.341***
	(0.083)	(0.066)	(0.022)	(0.018)	(0.043)	(0.043)	(0.022)	(0.016)
BDMA	-0.202***	-0.208***	-0.118***	-0.123***	-0.145***	-0.145***	-0.093***	-0.120***
	(0.054)	(0.034)	(0.022)	(0.022)	(0.019)	(0.019)	(0.022)	(0.017)
Asset Vol Ctrl	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Liquidity Ctrl	No	No	Yes	Yes	No	No	Yes	Yes
Macro Ctrl	No	No	No	Yes	No	No	No	Yes
R^2 in %	33.9	52.5	86.7	89.0	45.3	45.3	75.6	81.4
R^2 in % (adj.)	27.1	39.5	54.7	52.0	38.5	32.3	43.6	44.4
N	317	317	317	317	317	317	317	317

Table 7. Regressions of Correlations between Corporate Bond Returns and Government Bond Returns

The dependent variable in columns 1-4 is the correlation between monthly corporate bond portfolio and five-year CMT returns, and the dependent variable in columns 5-8 is the correlation between monthly asset-neutral corporate bond portfolio and five-year CMT returns, each estimated over the previous 36 months. We compute equal-weighted high priority (senior) and low priority (junior) bond portfolio returns using a common set of firms. For each corporate bond portfolio, the asset-neutral return is the average of individual asset-neutral bond returns on the non-financial firms, estimated as $R_{p,t+1} \equiv \Sigma_i w_{i,t}\left(R_{i,t+1} - \theta_{i,t} RA_{i,t+1}\right)$ based on the regressions in Table 4. The regressors are as described in Table 6, as is the adjustment to the R^2. The sample period is 1992-2012. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. The numbers in parentheses are Newey-West standard errors.

	Senior and Treasury Bonds				Asset-Neutral Senior and Treasury Bonds			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Const	0.763***	0.763***	0.763***	0.763***	0.815***	0.815***	0.815***	0.815***
	(0.051)	(0.039)	(0.031)	(0.018)	(0.038)	(0.031)	(0.028)	(0.017)
BDMA	-0.159***	-0.164***	-0.150***	-0.074**	-0.097***	-0.100***	-0.098***	-0.015
	(0.046)	(0.032)	(0.038)	(0.029)	(0.037)	(0.028)	(0.036)	(0.030)
Asset Vol Ctrl	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Liquidity Ctrl	No	No	Yes	Yes	No	No	Yes	Yes
Macro Ctrl	No	No	No	Yes	No	No	No	Yes
R^2 in %	43.9	63.3	72.6	85.7	33.0	53.2	58.0	76.4
R^2 in % (adj.)	37.1	50.3	40.6	48.7	26.2	40.2	26.0	39.4
N	317	317	317	317	317	317	317	317

	Junior and Treasury Bonds				Asset-Neutral Junior and Treasury Bonds			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.574***	0.574***	0.574***	0.574***	0.624***	0.624***	0.624***	0.624***
	(0.080)	(0.068)	(0.025)	(0.017)	(0.063)	(0.053)	(0.030)	(0.020)
BDMA	-0.290***	-0.296***	-0.223***	-0.162***	-0.181***	-0.185***	-0.123***	-0.015
	(0.053)	(0.035)	(0.032)	(0.030)	(0.059)	(0.042)	(0.040)	(0.046)
Asset Vol Ctrl	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Liquidity Ctrl	No	No	Yes	Yes	No	No	Yes	Yes
Macro Ctrl	No	No	No	Yes	No	No	No	Yes
R^2 in %	53.0	62.7	91.2	94.2	39.5	53.2	79.0	84.4
R^2 in % (adj.)	46.2	49.7	59.2	57.2	32.7	40.2	47.0	47.4
N	317	317	317	317	317	317	317	317

Table 8: Corporate Bond Betas

This table reports estimation results for the following three regressions:

$$R^{B_i}_{t,t+1} - R^F_t = \alpha + \beta\left(R^M_{t,t+1} - R^F_t\right) + \varepsilon_{t,t+1}$$

$$R^{B_i}_{t,t+1} - R^F_t = \alpha + \beta_1\left(R^{V_M}_{t,t+1} - R^F_t\right) + \beta_2\left(R^M_{t,t+1} - R^{V_M}_{t,t+1}\right) + \varepsilon_{t,t+1}$$

$$R^{B_i}_{t,t+1} - R^F_t = \alpha + \beta\left(R^{V_M}_{t,t+1} - R^F_t\right) + \varepsilon_{t,t+1}\ ,$$

where $R^{B_i}_{t,t+1}$ is the bond portfolio return, R^F_t is the one-month T-bill rate, and $R^M_{t,t+1}$ and $R^{V_M}_{t,t+1}$ are aggregate equity and asset returns. We form 4 x 2 x 2 bond portfolios three-way sorted by maturity, credit rating and priority. We report coefficient estimates, their heteroskedasticity-robust standard errors in parentheses, R^2s, and the number of securities in each portfolio. The column *Diff* reports the difference between the coefficient on $R^M_{t,t+1}$ in the first regression and that on $R^{V_M}_{t,t+1}$ in the third regression. These differences and their associated standard errors are estimated using GMM with an identity weighting matrix. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. The sample period is 1980-2012.

		Investment Grade						High Yield					
TTM	Priority	R^M	R^V	R^M-R^V	R^2 in %	*N*	*Diff*	R^M	R^V	R^M-R^V	R^2 in %	*N*	*Diff*
2-5 yrs	High	0.06^{***}			7.9	559	0.04^{***}	0.33^{***}			24.5	165	0.14^{***}
		(0.02)					(0.01)	(0.06)					(0.03)
			0.31^{***}	-0.52^{***}	24.3				0.69^{***}	-0.54^{***}	28.1		
			(0.05)	(0.10)					(0.14)	(0.33)			
			0.11^{***}		11.0				0.47^{***}		26.7		
			(0.02)						(0.07)				
	Low	0.07^{***}			9.3	559	0.05^{***}	0.24^{***}			18.6	188	0.11^{***}
		(0.02)					(0.01)	(0.06)					(0.02)
			0.31^{***}	-0.51^{***}	24.6				0.56^{***}	-0.59^{**}	22.9		
			(0.05)	(0.10)					(0.13)	(0.27)			
			0.12^{***}		13.2				0.35^{***}		20.8		
			(0.02)						(0.08)				
5-8 yrs	High	0.11^{***}			8.4	321	0.08^{***}	0.42^{***}			34.9	176	0.17^{***}
		(0.03)					(0.02)	(0.06)					(0.03)
			0.53^{***}	-0.90^{***}	26.7				0.78^{***}	-0.53	38.5		
			(0.08)	(0.16)					(0.17)	(0.36)			
			0.18^{***}		12.4				0.59^{***}		37.4		
			(0.04)						(0.09)				
	Low	0.11^{***}			10.0	321	0.08^{***}	0.39^{***}			28.3	176	0.16^{***}
		(0.03)					(0.02)	(0.07)					(0.03)
			0.50^{***}	-0.81^{***}	26.7				0.71^{***}	-0.47	31.1		
			(0.07)	(0.15)					(0.16)	(0.37)			
			0.19^{***}		14.2				0.55^{***}		30.3		
			(0.04)						(0.09)				
8-15 yrs	High	0.15^{***}			9.8	424	0.10^{***}	0.42^{***}			30.7	182	0.17^{***}
		(0.03)					(0.02)	(0.06)					(0.02)
			0.69^{***}	-1.15^{***}	28.6				0.80^{***}	-0.60^{*}	34.3		
			(0.09)	(0.19)					(0.15)	(0.37)			
			0.25^{***}		14.2				0.59^{***}		33.1		
			(0.05)						(0.08)				
	Low	0.14^{***}			9.3	424	0.09^{***}	0.41^{***}			32.5	182	0.17^{***}
		(0.03)					(0.02)	(0.07)					(0.03)
			0.64^{***}	-1.06^{***}	26.7				0.78^{***}	-0.56	36.2		
			(0.08)	(0.18)					(0.18)	(0.38)			
			0.23^{***}		13.4				0.58^{***}		35.0		
			(0.05)						(0.09)				
15 yrs or longer	High	0.19^{***}			8.6	429	0.13^{***}	0.30^{***}			18.3	97	0.15^{***}
		(0.05)					(0.02)	(0.07)					(0.03)
			0.85^{***}	-1.41^{***}	24.4				0.92^{***}	-1.34^{***}	29.3		
			(0.11)	(0.25)					(0.16)	(0.37)			
			0.31^{***}		12.3				0.45^{***}		22.1		
			(0.07)						(0.09)				
	Low	0.23^{***}			14.7	429	0.15^{***}	0.50^{***}			23.9	97	0.22^{***}
		(0.04)					(0.02)	(0.10)					(0.04)
			0.93^{***}	-1.45^{***}	34.2				1.17^{***}	-1.29^{***}	30.1		
			(0.10)	(0.22)					(0.20)	(0.47)			
			0.38^{***}		20.1				0.72^{***}		26.9		
			(0.06)						(0.13)				

Table 9: Corporate Security Loadings on Term and Default Factors

Panels A and B report coefficient estimates and their White robust standard errors from regressions of equity and corporate bond excess returns on stock and bond market factors for six value-weighted issuer-level credit rating portfolios. The stock market factors are the excess return on the market portfolio, the size factor, and the book-to-market factor from Ken French's website. We use two sets of bond market factors: TERM and DEF1 in Panel A and TERM and DEF2 in Panel B. TERM is the return on long-term government bonds, i.e., the average of 10-, 20-, and 30-year Treasury bond returns minus the 1-year T-bill return. DEF1 is the value-weighted average of investment-grade and high-yield bond index returns from Citi's Yieldbook minus the return on long-term government bonds used in TERM. DEF2 is the same aggregate corporate bond index return minus the 5-year Treasury bond return. Panel C reports the differences in the estimated coefficients on TERM and DEF between Panel A and Panel B and their standard errors from GMM estimation with an identity weighting matrix and a Bartlett kernel with four lags. The reported *p*-values are for one-sided tests that the differences are less than zero. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. The sample period is 1990-2012.

Panel A: DEF1

	AAA		AA		A		BBB		BB		B	
	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond
Const	0.00	0.00***	0.00	0.00***	0.00	0.00***	0.00	0.00**	0.00	0.00	-0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
RMRF	0.78***	-0.02**	0.80***	0.00	0.91***	-0.03***	0.94***	0.00	1.12***	0.07***	1.52***	0.21***
	(0.04)	(0.01)	(0.03)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.04)	(0.02)	(0.06)	(0.03)
SMB	-0.51***	-0.03***	-0.26***	-0.03***	-0.10***	-0.02**	-0.02	-0.02*	0.42***	0.06***	0.67***	0.15***
	(0.04)	(0.01)	(0.03)	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)	(0.04)	(0.02)	(0.07)	(0.03)
HML	0.00	-0.02**	0.06*	-0.01	0.04*	-0.02***	0.08***	-0.02*	0.05	-0.03*	-0.23***	-0.02
	(0.05)	(0.01)	(0.04)	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)	(0.04)	(0.02)	(0.08)	(0.03)
TERM	-0.12	0.67***	-0.13	0.75***	0.01	0.86***	0.18***	0.93***	0.22**	0.96***	0.33*	1.00***
	(0.10)	(0.02)	(0.08)	(0.02)	(0.05)	(0.02)	(0.07)	(0.02)	(0.10)	(0.04)	(0.17)	(0.08)
DEF1	-0.22*	0.44***	-0.30***	0.49***	-0.02	0.62***	0.27***	0.82***	0.53***	1.26***	0.62***	1.46***
	(0.12)	(0.03)	(0.10)	(0.03)	(0.06)	(0.02)	(0.08)	(0.03)	(0.12)	(0.05)	(0.21)	(0.09)
N	269	269	269	269	269	269	269	269	269	269	269	269
R^2 in %	70.9	83.7	78.3	85.4	92.4	93.6	90.4	89.0	89.0	83.2	84.4	74.5

Panel B: DEF2

	AAA		AA		A		BBB		BB		B	
	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond
Const	0.00	0.00^{***}	0.00	0.00^{***}	0.00	0.00^{***}	0.00	0.00^{***}	0.00	0.00^{***}	-0.01^{**}	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
RMRF	0.79^{***}	0.00	0.80^{***}	0.03^{***}	0.90^{***}	0.00	0.94^{***}	0.03^{**}	1.11^{***}	0.08^{***}	1.51^{***}	0.22^{***}
	(0.04)	(0.01)	(0.03)	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.04)	(0.02)	(0.06)	(0.03)
SMB	-0.50^{***}	-0.04^{***}	-0.26^{***}	-0.03^{**}	-0.10^{***}	-0.02^{*}	-0.03	-0.03^{*}	0.41^{***}	0.04^{**}	0.65^{***}	0.13^{***}
	(0.04)	(0.01)	(0.03)	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)	(0.04)	(0.02)	(0.07)	(0.03)
HML	0.01	-0.02	0.06^{*}	0.00	0.04^{*}	-0.01	0.08^{***}	-0.01	0.04	-0.03	-0.24^{***}	-0.02
	(0.05)	(0.01)	(0.04)	(0.01)	(0.02)	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)	(0.08)	(0.04)
TERM	0.02	0.37^{***}	0.07	0.42^{***}	0.02	0.44^{***}	0.00	0.38^{***}	-0.13^{**}	0.12^{***}	-0.07	0.03
	(0.05)	(0.01)	(0.04)	(0.02)	(0.03)	(0.01)	(0.03)	(0.02)	(0.05)	(0.02)	(0.09)	(0.04)
DEF2	-0.23^{*}	0.31^{***}	-0.28^{***}	0.31^{***}	0.02	0.45^{***}	0.24^{***}	0.63^{***}	0.54^{***}	1.09^{***}	0.66^{***}	1.31^{***}
	(0.12)	(0.03)	(0.09)	(0.03)	(0.06)	(0.03)	(0.08)	(0.04)	(0.11)	(0.06)	(0.20)	(0.09)
N	269	269	269	269	269	269	269	269	269	269	269	269
R^2 in %	70.9	76.4	78.2	76.9	92.4	83.4	90.4	76.7	89.1	75.7	84.5	72.3

Panel C: Cross-Equation Differences

	AAA		AA		A		BBB		BB		B	
	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond	Equity	Bond
TERM	-0.15^{*}	0.30^{***}	-0.20^{***}	0.33^{***}	-0.01	0.42^{***}	0.18^{***}	0.55^{***}	0.35^{***}	0.84^{***}	0.41^{***}	0.97^{***}
	(0.09)	(0.05)	(0.06)	(0.04)	(0.05)	(0.03)	(0.06)	(0.05)	(0.10)	(0.09)	(0.14)	(0.07)
p-value	0.95	0.00	1.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DEF	0.00^{*}	0.13^{**}	-0.02^{**}	0.18^{**}	-0.04^{**}	0.18^{**}	0.03^{**}	0.19^{**}	-0.01^{*}	0.18^{*}	-0.04^{*}	0.14^{*}
	(0.06)	(0.03)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.06)	(0.06)	(0.10)	(0.08)
p-value	0.47	0.00	0.64	0.00	0.82	0.00	0.21	0.00	0.54	0.00	0.66	0.04

Table 10: Time-Variation in Expected Returns on Corporate Securities

Coefficient estimates and their standard errors, in parentheses, from predictive regressions of equity, bond, and asset excess returns on the dividend yield, term spread, and default spread over the period 1990-2012. The equity, bond, and asset returns are value-weighted returns based on all firms in the sample with an available issuer-level credit rating. The dividend yield, DP, is constructed following Fama and French (1988). The term spread, YS, is the ten-year CMT yield minus the three-month T-bill yield. The default spread, DEF(KS), is the yield on the high-yield market index from Citi's Yieldbook minus the three-month T-bill yield, following Keim and Stambaugh (1986). The column Equity-Asset reports the difference in coefficients between the equity and asset predictive regressions, estimated via GMM with an identity weighting matrix. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels. Standard errors are Newey-West adjusted using four lags.

	Equity	Bond	Asset	Equity-Asset
Const	-0.01	-0.01***	-0.01	
	(0.01)	(0.00)	(0.01)	
DP	1.46***	0.31	1.18***	0.28**
	(0.55)	(0.19)	(0.43)	(0.12)
YS	-0.07	0.00	-0.07	0.00
	(0.30)	(0.10)	(0.24)	(0.08)
DEF(KS)	-0.20	0.09**	-0.12	-0.08*
	(0.13)	(0.05)	(0.10)	(0.04)
N	256	256	256	
R^2 in %	1.86	5.95	1.77	

Table 11: Understanding Default and Term Premiums in Equity Returns

Coefficient estimates and their Newey-West standard errors, in parentheses, from predictive regressions of excess equity returns on the dividend yield, term spread, and two alternative measures of the default spread over the period 1990-2012. The dividend yield and term spread are as described in Table 10. The first default spread measure, DEF(KS), based on Keim and Stambaugh (1986), is the difference between the yield on a high-yield bond index and the three-month T-bill yield. The second measure, DEF(FF), based on Fama and French (1989), is the difference between the yields on a high-yield bond index and a AAA-rated corporate bond index. The column KS-FF reports the differences in the coefficient estimates from the two regressions, estimated via GMM with an identity weighting matrix. The reported *p*-values are based on the one-sided test that the differences are less than zero. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels.

	KS	FF		KS - FF
Const	-0.01	-0.01	DP	-0.15
	(0.01)	(0.01)		(0.10)
DP	1.46***	1.61***	*p*-value	0.94
	(0.55)	(0.57)		
YS	-0.07	-0.29	YS	0.22
	(0.30)	(0.24)		(0.19)
DEF(KS)	-0.20		*p*-value	0.14
	(0.13)			
DEF(FF)		-0.27*	DEF	0.07**
		(0.16)		(0.04)
N	256	256	*p*-value	0.04
R^2 in %	1.86	2.05		

Figure 1. Durations of Corporate Securities in a Stochastic Interest Rate Model

This figure plots the durations of senior debt, junior debt, and equity for the model given in Section II.A. The parameter values are $r = 5\%, \sigma = 20\%, \tau = 5, K_S = 25, K_J = 25, q = 0.20, v = 2\%, m = 7\%$.

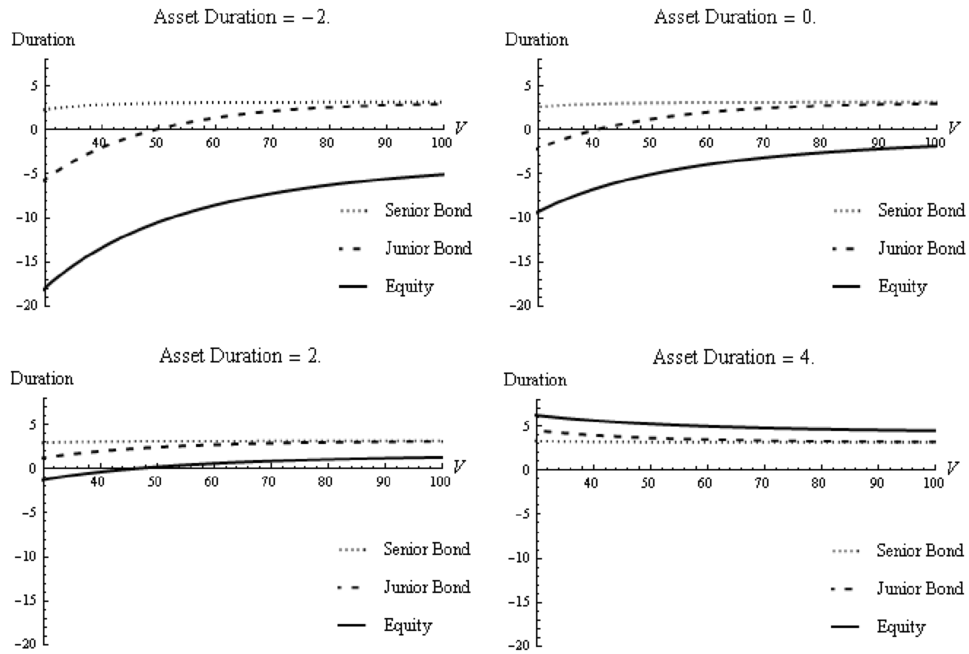


Figure 2. Aggregate Leverage and Equity-Government Bond Return Correlations

The solid line plots the correlation between monthly aggregate equity returns and government bond returns, estimated using data over the previous 36 months. The long-dashed line plots this same correlation with equity returns adjusted for their estimated asset duration. The short-dashed line plots an inverse measure of aggregate market leverage, that is, market value of the assets over book value of debt. The left axis measures correlation and the right axis measures leverage. The sample period is 1985-2012.

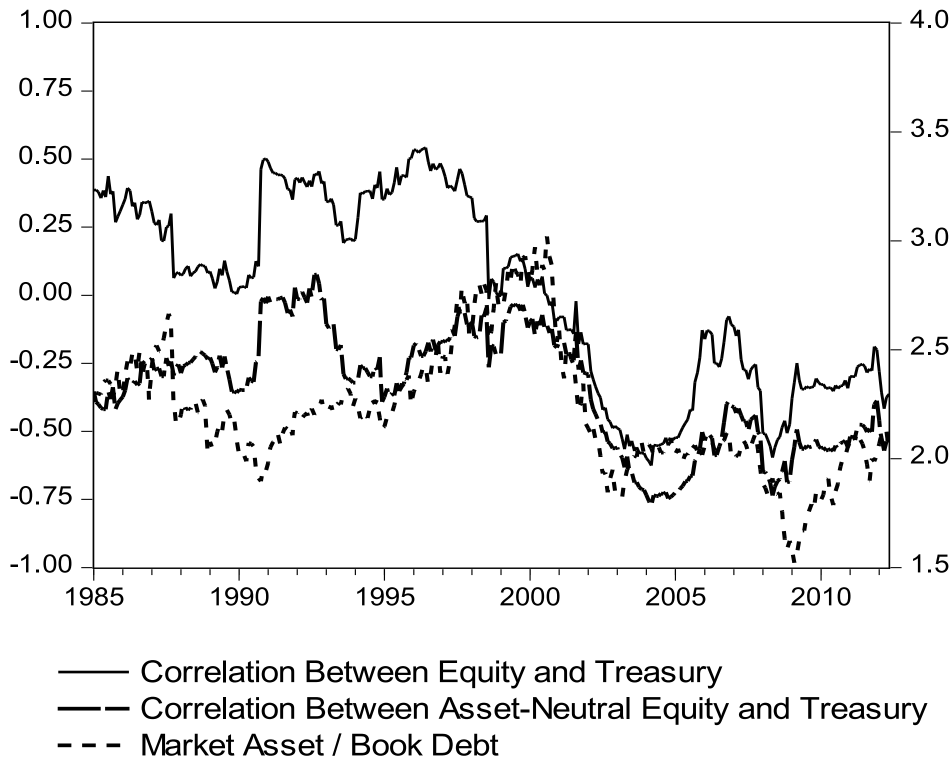


Figure 3. Time-Series of Time Fixed Effects for the Correlation Between Equity and Government Bond Returns

This figure plots time fixed effects and their 95%-confidence intervals from pooled time-series regressions of equity-government bond return correlations over the period 1985-2012. The black line plots the time fixed effects from regressions without any control variables. The gray line plots time-fixed effects estimated with both leverage and asset duration controls.

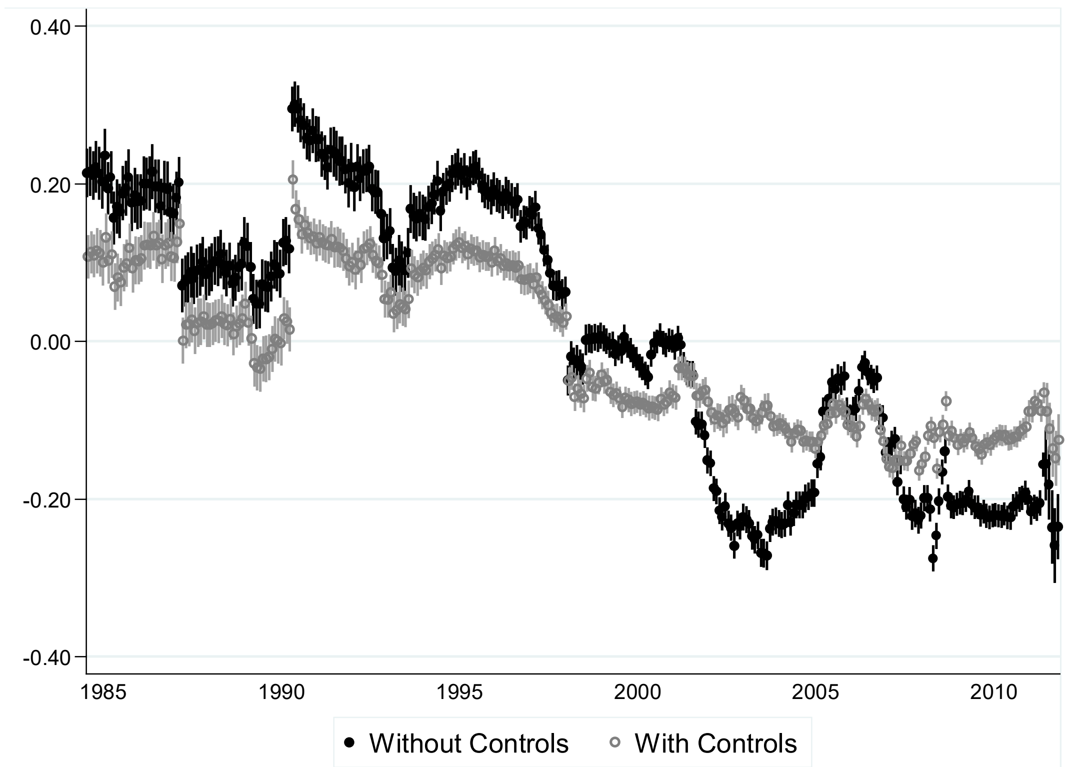
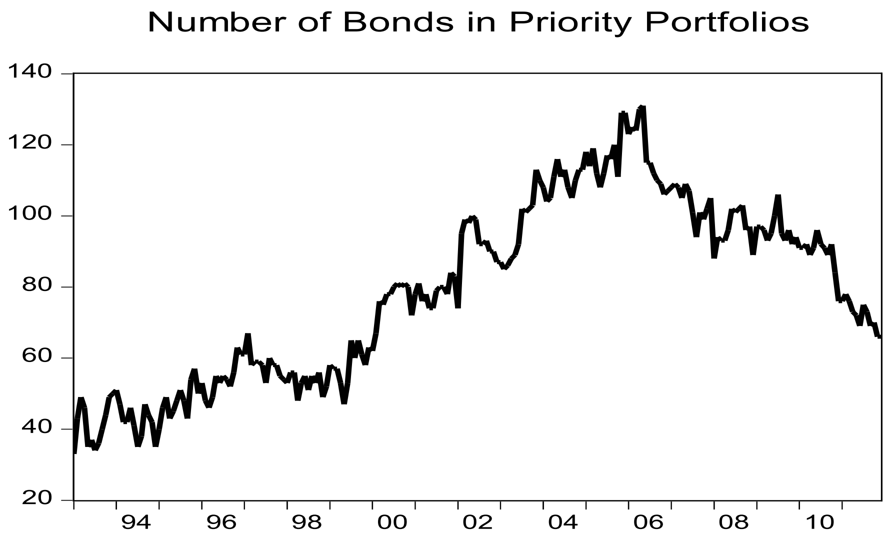


Figure 4. Characteristics of Matched High and Low Priority Corporate Bond Portfolios

The figure plots the number of bonds and their average ratings for two portfolios of corporate bonds, high priority and low priority, from a common subset of firms. By construction, the two portfolios have the same number of bonds. The sample period starts in 1992 to ensure that the portfolios contain at least 30 bonds.



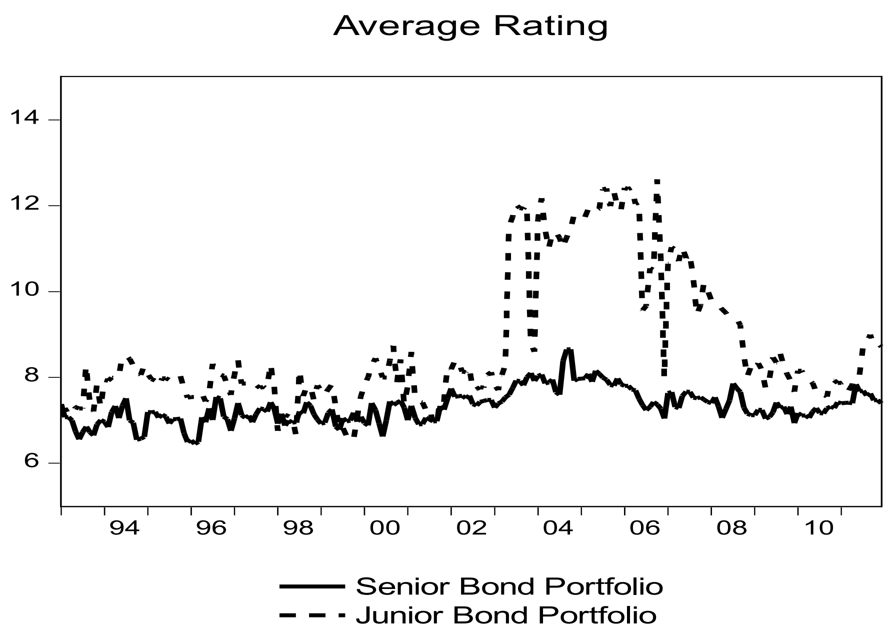
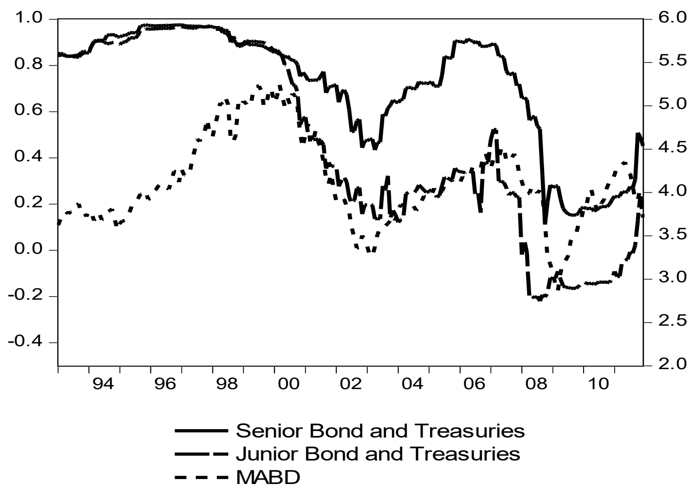


Figure 5. Aggregate Leverage and Corporate Bond-Government Bond Return Correlations

The figure plots correlations of monthly government bonds returns with the returns on equally weighted portfolios of high and low priority corporate bonds, estimated over the previous 36 months, along with an inverse measure of aggregate market leverage, namely market value of the assets over book value of debt (MABD). The first figure graphs correlations based on raw corporate bond returns, while the second figure adjusts the corporate bond returns for the estimated firm asset duration. The two portfolios contain corporate bonds from a common set of firms. By construction, the two portfolios have the same number of bonds. The sample period starts in 1992 to ensure that the portfolios contain at least 30 bonds.

Correlation Between Bond Portfolios and Treasury Returns



Correlation Between Treasury and Asset-Neutral Bond Returns