On the Interest Rate Sensitivity of Corporate Securities

Jaewon Choi[a], Matthew Richardson[b] and Robert F. Whitelaw[c*]

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Abstract

We use contingent claim asset pricing and exploit capital structure priority to better understand the relation between corporate security returns and interest rate changes. We show theoretically and confirm empirically that the interest rate sensitivity, or duration, of a security within a firm's capital structure is monotonically related to the priority of the security. The magnitude of the effect of priority on duration depends on the firm's market leverage. Importantly, we document that equity is naturally a negative duration asset. The empirical use of priority is novel to the literature. These findings at the firm level have important implications for aggregate phenomena: (i) interpreting the time-varying correlations between the returns on government bonds and those on aggregate stock and debt markets, and (ii) developing joint factor models for bonds and stocks.

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[a] University of Illinois, Gies College of Business, 1206 S. Sixth St., Champaign, IL 61820, Phone: +1 217 244 0840, Email: jaewchoi@illinois.edu. [b] New York University, Stern School of Business, 44 W. 4th Street, New York, NY 10012, and NBER, Phone:+1 212 998 0349, Email: mrichar0@stern.nyu.edu. [c] New York University, Stern School of Business, 44 W. 4th Street, New York, NY 10012, and NBER, Phone: +1 212 998 0338, Email: rwhitela@stern.nyu.edu.

I. Introduction

Why do stock and bond markets move in opposite directions? In contrast to standard explanations, which relate business cycles to aggregate comovements in bond and equity markets, this paper appeals to structural models of capital structure valuation (in the spirit of Merton (1974)) that have been employed at the security level. The important insight is that, even under the assumption that the value of a firm's assets is independent of market interest rates, one would expect lower priority securities in the capital structure, such as subordinated or distressed debt and equity, to have low or even negative durations (i.e., positive interest rate sensitivity). Intuitively, the lower priority securities are effectively short higher priority fixed rate debt, i.e., they are short the bond market. Consequently, it is critical to map the capital structure and priority structure of firms to understand the comovement of stock and bond markets.

While the models in this paper are not new, our theoretical analysis incorporating the joint impact of priority and leverage on the interest rate sensitivity across the capital structure is novel. Our predictions are carefully 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. Using carefully derived implications from Merton-type models, we empirically analyze how the interest-rate sensitivity of corporate securities depends on leverage and the security's priority within the capital structure.

We empirically analyze the effect of a security's priority on the relationship between the security's return and interest rate changes. We provide three main findings in our firm-by-firm analysis. First, we show that for firms sorted by their market leverage, simple estimates of the interest rate duration of corporate securities increase with priority. For example, for leverage quintile 1, i.e., firms with the lowest but non-zero levels of leverage, our duration estimates using five-year constant maturity Treasury (CMT) yield changes are -1.70, 2.22, and 2.90 for equity, junior debt, and senior debt, respectively. Second, we control for the asset duration of the firm by examining the duration differences across securities with different priority within the capital structure of a firm, and we again confirm that lower priority securities have lower durations. For example, equity has a duration for 5-year CMT yield changes 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, where interest rate sensitivity is modeled as a function of leverage and priority, and where we control for firm-specific characteristics and the interest rate sensitivity of asset returns. For the most part, we document that the duration of a corporate security is negatively related to the firm's 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 latter priority effect is both statistically and economically significant. For example, the duration of a senior bond in the firm's capital structure for 5-year CMT yield changes is 10.9% higher than the duration of an otherwise equivalent junior bond.

An important corollary of the results on corporate securities' interest rate sensitivity at the firm level is that these findings should have a first-order implication for analogous quantities at the market level. Intuitively, because aggregate stock and corporate bond indices represent portfolios of individual securities, the relevance of priority and leverage for explaining the interest rate sensitivities of individual securities should aggregate up. We use this logic to address two questions of interest to financial economists.

First, what implications does our firm-by-firm analysis have for the heavily studied empirical relation between aggregate index returns and interest rate changes, with the S&P500 and government bonds being the most studied? (See, 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). Not one of these papers points to leverage and the priority structure at the firm level as an important factor. We show theoretically that the average leverage of the firms included in the index and the average priority of the securities within the index should play a role in describing the correlation between corporate bond and equity index returns and interest rate changes. This implication is confirmed empirically, and the effect is large. For example, a one standard deviation increase in leverage decreases the government bond-equity correlation by 0.20. Also, when comparing the correlation of government bonds to corporate bond portfolios of senior and junior debt of the same firms, a one-standard deviation increase in the average leverage of the portfolio leads to a 13% larger drop in the correlation for the junior debt versus senior debt portfolio.

Second, what implications does our firm-by-firm analysis have for the multivariate factor structure of expected returns of stocks and bonds? We explore three issues: (i) interpreting the commonly used term premium and default premium risk factors, (ii) measuring the betas of corporate bonds, and (iii) developing joint models for time-varying expected returns of bonds and stocks. With respect to these topics in the literature, no attention has been given to the impact of the relative location of stocks and bonds within a firm's capital structure. Exploiting the structural relationship between stocks and bonds based on their capital structure priority, we document new results and reinterpret some existing empirical findings in this context.

The paper is organized as follows. Section 2 places this paper in the context of the existing literature. Section 3 lays out the implications of the Merton (1974) model for the interest rate sensitivity of corporate securities across the capital structure. Section 4 empirically analyzes these implications using firm-by-firm data. Section 5 explores the implications of these findings for aggregate effects for bonds and stocks, and then provides corroborating empirical evidence. Section 6 concludes.

II. Relationship to Existing 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 similarly 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 common covariation between stocks and bonds can derive from shocks to real and nominal aggregate cash flows,[1] changing expected returns,[2] or, in light of the lack of success of some of these asset pricing models, aggregate behavioral

[1] 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.
[2] 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.

phenomena.[3] In particular, a number of papers have tried to explain the periods in which equity returns and bond returns have been negatively correlated. From a theoretical point of view, while the engine underlying the consumption-based asset pricing paradigm links all long-term securities through a common pricing factor, the underlying models can be tweaked to generate different relationships between stock and bond returns.[4]

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.[5] However, Blume, Keim, and Patel (1991) and, more recently, Schaefer and Strebulaev (2008) have had success in documenting comovements between equity returns and corporate bonds that are consistent with contingent claims pricing models. Interestingly though, Schaefer and Strebulaev (2008) note that these models are unable to match the interest rate sensitivity of corporate debt, which is substantially lower than that implied by standard duration measures.[6] Our paper adds to this literature by measuring the interest rate sensitivity of all corporate securities (debt and equity) by exploiting the joint implications of priority and leverage within contingent claim pricing models.

On the theory side, our paper relies on Merton (1974) and Chance (1990) to derive relationships between corporate security returns and interest rate changes in terms of the security's priority and firm's leverage. These testable implications are novel to the literature. Using more advanced models than Merton (1974), Ramaswamy and Sundaresan (1993) and Longstaff and Schwartz (1995) in particular also derive new relationships between corporate bonds and interest rate changes. However, neither of these papers model the impact of priority structure on the interest rate sensitivity of corporate debt or investigate the relationship between equity returns and interest rates. Related to our paper, one of the results derived by Longstaff and Schwartz (1995) is that the interest rate sensitivity is lower for riskier bonds. In their model, this can arise because of the correlation between a firm's asset returns and interest rate changes. In contrast, our point is quite

[3] 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 the stock and bond return covariation.
[4] See Campbell (2000), Campbell, Sunderam and Viceira (2013) and Koijen, Lustig, and Van Nieuwerburgh (2012) for examples of such asset pricing models.
[5] See 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.
[6] This finding confirms earlier results in, for example, Fons (1990), Longstaff and Schwartz (1995), and Duffee (1998).

different. Even if asset values are independent of interest rates, the duration of corporate securities (including equity) will be monotonic in priority.

On the empirical side, our paper is the first paper to relate the interest rate sensitivity of corporate securities to their joint properties of 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 ratings 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 are a sufficient measure for leverage and priority, our focus is on documenting the true fundamental relationship, not credit ratings agencies' take on this relationship. This point aside, there is also considerable evidence that credit ratings do not capture all current 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)). That said, we investigate whether priority remains significant and/or credit ratings add explanatory power when credit ratings are added to the regression analysis. With respect to Schaefer and Strebulaev (2008), who investigate individual bond returns and control for equity returns and thus provide an analysis closest to ours, they document lower than expected interest rate sensitivity 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, priority and asset values also produces higher interest rate sensitivity.

III. Theoretical Framework and Empirical Methodology

In this section, we present the theoretical framework and provide the corresponding intuition for the relation between the returns on corporate securities and risk-free interest rates, which we later take to the data. The analysis follows Merton (1974) and Chance (1990), with the key assumptions being that corporate liabilities take the form of zero-coupon, fixed rate debt. We also allow for stochastic interest rates, where the shock to interest rates can be correlated with innovations in the value of the firm's assets. Comparative statics from this model provide the key intuition for how interest rate sensitivity varies with priority.[7]

A. Theoretical Framework

Following Merton (1974), we make the standard assumptions that the nominal value of the firm's assets follows a geometric Brownian motion under the risk neutral measure, [8]

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

where r is the instantaneous (nominal) risk-free rate, σ_V is the volatility of the firm's assets, 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. As in Vasicek (1977), we further assume that r_t follows the mean-reverting process

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

where q is the speed of mean reversion, m is the long run mean of the interest rate, W is a standard Brownian motion, and the correlation between the shocks to interest rates and firm asset value is ρ, i.e., $\mathrm{E}[(dZ)(dW)] = \rho\,dt$, again all under the risk neutral measure.[9] This correlation captures the interest rate sensitivity of assets, i.e., asset duration.

Following Merton (1973), Rabinovitch (1989), Shimko et al. (1993), and Schaefer and Strebulaev (2008), the price of a put option written on the firm's assets is

[7] 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.

[8] The risk premium on the assets is irrelevant for the results that follow, so for ease of exposition all calculations are done under the risk neutral measure.

[9] 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.

$$
\begin{aligned}
&P(V,K,\tau,r,\sigma_V) = K\cdot B(\tau,r)\cdot N(-d_2) - V\cdot N(-d_1)\\
&B(r,\tau) = Ae^{-rC}\\
&A = e^{k(C-\tau)-(vC/2)^2/q}\\
&C = (1-e^{-q\tau})/q
\end{aligned}
\quad , \qquad (1)
$$

where K is the strike price, τ is the maturity of the option, and k is a constant defined as $k = m-(v/q)^2/2$. $B(\tau,r)$ is the price of a default-free zero coupon bond of the same maturity τ. The arguments d_1 and d_2 in the cumulative normal distribution function $N(\cdot)$ are defined as

$$
\begin{aligned}
&d_1 = \frac{ln\left(V/(K\cdot B(r,\tau))\right)+T/2}{\sqrt{T}}\\
&d_2 = d_1 - \sqrt{T}\\
&T = \sigma^2\tau + \left(\tau - 2C + (1-e^{-2q\tau})/(2q)\right)\left(v/q\right)^2 - \left(2\rho\sigma(\tau-C)v\right)/q
\end{aligned}
$$

Using the above valuation, we can price various contingent claims on the firm. For simplicity and to build intuition, 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 and maturity τ (denoted D_s) and zero-coupon junior debt with face value K_j and maturity τ (denoted D_j). 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:

$$
\begin{aligned}
&D_s = K_s B(\tau,r) - P(V,K_s,\tau,r,\sigma_V)\\
&D_j = K_j B(\tau,r) + P(V,K_s,\tau,r,\sigma_V) - P(V,K_s+K_j,\tau,r,\sigma_V)\,,\\
&E = V + P(V,K_s+K_j,\tau,r,\sigma_V) - (K_s+K_j)B(\tau,r)
\end{aligned}
\qquad (2)
$$

where $P(\cdot)$ is the value of a European put given above. 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. Junior debt equals a default-free bond minus the difference of two put options on the underlying assets, with exercise prices equal to K_s+K_j and 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, i.e., a default-free bond minus a put option on the underlying assets with an exercise price equal to the face value

K_s+K_j. The key insight is that equity takes on a short position in the underlying debt and therefore has a tendency to increase in value with positive interest rate changes. More subtly, junior debt exhibits a similar phenomenon as it and the senior debt above it become sufficiently risky.

Throughout, we will define interest rate sensitivity as the negative of the percentage change in the value of the security for a change in the interest rate, i.e., modified duration (hereafter simply duration), which is the continuous time counterpart to the negative of the slope coefficient in the regressions we run later of security returns on interest rate changes.[10] One can also view this quantity as the magnitude of the short position in interest rates 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)

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

For the financial claims on these assets, the durations are

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

The durations of the contingent claims consist of two components. The second term is the interest rate sensitivity of the claim holding asset value fixed, which is the quantity of primary interest. The first term is the asset duration multiplied by the elasticity of the claim with respect to the value of the assets. This term captures how the asset duration transfers to a contingent claim, which indicates that it may be necessary to control for the duration of assets in our empirical analysis if asset durations differ significantly from zero.

[10] Since we are working in a 1-factor interest rate world, we could easily redefine this duration with respect to the change in yields on risk-free bonds at any maturity with similar results.

To illustrate how durations can vary over time and across firms, Figure 1 graphs the modified durations of senior debt, junior debt and equity as a function of the firm's asset value for various values of asset duration (achieved by changing the correlation, ρ). Since the face value of the debt is fixed (at 50 for this exercise), 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 is large relative to the face amount of the debt K_s+K_j, the senior and junior debt both have modified durations equal to the modified duration of a default-free bond with the same maturity. The modified 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.

Second, and of particular importance, there is a general ordering of modified 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 the case empirically, then duration declines as the claim becomes more junior as illustrated in the first 3 panels in Figure 1 (asset durations of -2, 0 and 2). The intuition is that the second component of duration derived above dominates, i.e., what matters is the direct interest rate sensitivity of the various claims.

Considering only this component, which is equivalent to focusing on the second panel where the asset duration is zero, senior debt always has a positive duration (i.e., negative interest rate sensitivity) while equity always has a negative duration (i.e., positive interest rate sensitivity). The sign of the duration for junior debt is ambiguous, depending on the degree of leverage of the firm as measured by V relative to K_s and K_s+K_j.

Allowing for a non-zero asset duration of a sufficiently small magnitude does not change the ordering, but it changes the durations to which the claims converge, i.e., equity duration converges to asset duration as firm value increases, and senior debt duration converges to asset duration as firm value decreases. Moreover, negative (positive) asset durations increase (decrease) the duration spread between the claims because the asset duration effect works in the same (opposite) direction as the direct interest rate sensitivity. Note also that equity duration can change signs from negative to positive as leverage decreases (the 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, and these switches occur at firm values that are inversely related to asset duration. In the extreme case depicted in the fourth panel when the asset duration exceeds the duration of the risk-free senior debt, then the ordering is reversed. The asset duration effect dominates and the lower priority claims are more exposed to this effect.

Since the modified duration of a portfolio of financial assets is just a market value-weighted sum of the modified durations of these assets, popular indices such as the S&P 500, the Dow Jones 30, and various corporate bond indices 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. 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 (e.g., 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. For example, there is a well-known literature that argues that inflation 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 (e.g., Shiller and Beltratti (1992) and Campbell, Sunderam, and Viceira (2013)).[11]

The remainder of this paper focuses on measuring the modified durations of corporate claims in light of the above theoretical framework and reinterpreting existing results that tend to ignore the implications of the contingent claims approach for the relation between equity returns and interest rate changes.

B. Empirical Methodology and Implications

Recall from Section III.A 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 assets multiplied by the elasticity of the claim with respect to this interest rate sensitivity. The former effect is our primary focus; thus, to control for the latter effect in our empirical analysis, note that for a generic security with value *D,*

$$\begin{aligned} \frac{dD_t}{D_t} &= \left(\frac{\partial D/D}{\partial t} + \frac{1}{2}\frac{\partial^2 D/D}{\partial V^2} \right) dt + \frac{\partial D/D}{\partial V/V}\left(\frac{dV_t}{V_t} - rdt \right) + \frac{\partial D/D}{\partial r}\left(dr - q(m-r)dt \right) \\ &= \left(\frac{\partial D/D}{\partial t} + \frac{1}{2}\frac{\partial^2 D/D}{\partial V^2} - \frac{\partial D/D}{\partial V/V} r_t - \frac{\partial D/D}{\partial r} q(m-r_t) \right) dt + \frac{\partial D/D}{\partial V/V}\frac{dV_t}{V_t} + \frac{\partial D/D}{\partial r} dr_t \end{aligned} \tag{5}$$

Under the physical measure, the drift term is just the expected return on the security, which we assume is constant. Therefore, the regression specification for estimating duration becomes

[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.

$$R_t = \alpha + \frac{\partial D / D}{\partial V / V} \cdot RA_t + \frac{\partial D / D}{\partial r} \Delta i_t + \varepsilon_t \tag{6}$$

where RA_t is the return on the assets of the firm and i_t is the interest rate.

The theoretical results in Section III.A show that what matters for a security's interest rate sensitivity is its location within the capital structure of the firm and the relative value of the firm's assets V to its outstanding liabilities, along with the firm's asset duration.[12] Therefore, given a mapped out capital structure for each firm, we want to measure the sensitivity of the particular security's return to interest rates as a function of where it is in the priority structure of the firm. Equation (6) relates the return on a corporate security to the return on assets of the firm and interest rate changes with time-varying coefficients that depend on the security's priority and the leverage of the firm.

The intuition is as follows. Under the assumption that asset duration is zero, the coefficient of a regression of security returns on interest rate changes will vary with the priority of the security and the "financial health" of the firm (i.e., the market value of its assets relative to the book value of its debt obligations). However, if asset duration is nonzero, it may be necessary to control for this effect as argued above. For example, suppose interest rate changes are proxying for other variables that impact the real value of the firm. If interest rates affect the value of the assets, the impact on the different debt issues and equity will not be proportional but governed by the capital structure. If V is relatively high, and debt is safe, then an increase in asset value due to interest rate changes will accrue primarily to equity.

We implement a natural functional form for equation (6) that incorporates the asset return effect, as well as priority (P) and leverage (L). For bonds, our specification is,

$$R_{t+1} = \alpha + \beta_t \tau_t (-\Delta i_{t+1}) + \theta_t RA_{t+1} + \epsilon_{t+1} \tag{7}$$

where β_t and θ_t are parametrized as $\beta_t \equiv \beta_0 + \beta_1 L_t + \beta_2 P_t + \beta_3 L_t P_t + \beta_4 Z_t$ and $\theta_t \equiv \theta_0 + \theta_1 L_t + \theta_2 P_t$, respectively; τ_t is the time-to-maturity of the bond;[13] L_t is the leverage of the firm

[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] More precisely, we use the coupon-weighted time-to-maturity.

defined as log book debt divided by market assets; P_t is the priority of the bond defined as one minus the fraction of bonds (face value) 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 return on the firm's assets; and Δi is the change in the five-year, CMT yield.[14] 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.

For equity, we estimate a slightly simplified version of equation (7), where we drop the time-to-maturity interaction τ_t by setting the maturity equal to one, and the coefficients are parameterized as $\beta_t \equiv \beta_0 + \beta_1 L_t$ and $\theta_t \equiv \theta_0 + \theta_1 L_t$. There is no variation in the priority of equity across firms or over time, and there are no equity specific characteristics. In this case, the coefficient β_t is the duration of equity, and the interpretation of equation (7) is that we are estimating the effect of leverage on this duration. For assets, we further drop the asset return term, and the interpretation of equation (7) is that we are estimating the correlation between leverage and asset duration with no causality implied. For asset duration close to zero, the theoretical framework and Figure 1 above imply that (i) $\beta_t < 0$ for equities, $\beta_t > 0$ for senior debt, and β_t has an ambiguous sign for junior debt; (ii) β_t is monotonically increasing in priority (i.e., $\beta_2 > 0$), and (iii) β_t is decreasing in leverage (i.e., $\beta_1 < 0$). For asset duration much greater than zero (i.e., greater than the highest priority debt), Figure 2 implies that (i) $\beta_t > 0$ for equities, senior debt, and junior debt; (ii) β_t is monotonically decreasing in priority (i.e., $\beta_2 < 0$), and (iii) β_t is increasing in leverage (i.e., $\beta_1 > 0$).

[14] 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 5-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 1-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.

IV. The Interest Sensitivity of Corporate Security Returns: Firm-Level Evidence

There is a fairly extensive empirical literature over the past three decades analyzing contingent claim pricing models of the firm. The evidence in these studies is mixed at best. 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 contingent claim pricing of corporate liabilities are not borne out in the data though others take exception to this conclusion, e.g., Ericsson, Jacobs, and Oviedo (2009). Moreover, several papers find some support for the theory, in particular, by documenting comovements between equity returns and higher yielding bonds (e.g., Blume, Keim, and Patel (1991) and Schaefer and Strebulaev (2008)). Our paper focuses on a specific aspect of contingent claim pricing, namely the exposure of different securities within the capital structure to interest rate changes, i.e., duration (e.g., see Duffee (1998), Strebulaev and Schaefer (2008) and Huang and Shi (2016) for measuring corporate bond durations).

Our strategy is as follows. First, to the extent possible, we map out the capital structure for each firm in our sample. Second, on a firm-by-firm basis, we analyze the implications of equations (4) and (7), and Figure 1. Specifically, at the individual firm level, given a mapped out capital structure, we measure the sensitivity of the particular security's return to interest rates as a function of where it is in the priority structure of the firm.

A. Data Description

In order to map out the capital structure and construct the returns on a firm's assets, we need to utilize a number of datasets including (i) CRSP for equity prices, (ii) the Bridge EJV database from Reuters for corporate bond prices and details,[15] (iii) the FISD from Mergent for

[15] 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 its importance 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.

additional corporate bond details and verification of the EJV data, (iv) Dealscan and the mark-to-market pricing services from Loan Pricing Corporation for loans, (v) Compustat for the face value of debt and other accounting information, and (vi) 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). As a result, we only summarize the data and stylized facts relevant for our problem.

Table 1 summarizes the coverage of our sample relative to the usual CRSP/Compustat universe. For the sample period during which we have data on both bonds and loans, Table 1, Panel A shows that our data cover 96.2% and 89.6% of the debt structure on an equal-weighted and value-weighted basis, respectively. A little over one-third of the capital structure is in the form of loans. Panel B documents how many of the firms' capital structures include fixed-rate bonds with multiple priority levels. Specifically, 70.0% of the capital structures in terms of the number of observations contain bonds of just one priority while 21.0% have two, 7.3% three, and 5.7% four or more. Panel B further breaks down each multi-priority capital structure into low and high priority components as a percentage of total assets. The panel shows that, on average for each firm, there is a nice mix of high and low priority bonds. Panel C provides the distribution of one key variable in Figure 1, namely the market value of the assets divided by the book value of debt. For example, over 75% of the observations involve market assets 87% greater than the book value of debt.

Assuming that the results of Modigliani and Miller (1958) hold, the firm's assets and liabilities exactly offset, and we can calculate the return on the firm's assets as the weighted average return of 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.[16] Note that out datasets map out financial liabilities of firms and do not cover non-

[16] 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 Loan Pricing Corporation (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

financial liabilities such as trade credit and account payables. Our measures of asset returns are still good proxies of firms' assets, as these other liabilities are typically small and show little change in value over time.

In terms of each individual component, 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 the quoted bond prices, coupon payments and accrued interest.[17] The more tricky calculation revolves around the returns of 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.[18] For the sample period in which the loan data are coincident with the bond data, 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 apply an alternative approach to 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 returns 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 (and for periods) when bank loan data are not available.[19]

B. Preliminary Estimates of Durations of Corporate Securities

As a first pass, Table 2 summarizes estimates of the modified duration for different classes of securities as a function of the market value of the assets relative to the debt outstanding. In particular, we estimate the following equation for firms that have both high and low priority bonds:

$$R_t^i = \alpha + \beta(-\Delta i_t) + \varepsilon_t \qquad (8)$$

of investment grade firms tend to trade around par if their coupon rates float. For the coincident period in which we have access to both bond and loan data, Table 1 shows that over 90% of the capital structure is covered.

[17] When a bond price is missing in a particular month, 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. Interpolation occurs in 0.91% of the sample.

[18] 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.

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

We estimate β for (i) firms' assets (as constructed above), (ii) higher priority debt issues of medium-term maturity (as long as they cover 10% of the capital structure and are neither convertible nor callable), (iii) lower priority debt issues of medium-term maturity (as long as they cover 10% of the capital structure and are neither convertible nor callable), and (iv) equity. Note that equation (8) is a simplified version of the fundamental model in equation (4) and its empirical counterpart in equation (7). These calculations are provided over 5 ranges of market leverage, namely from high leverage to zero leverage. We use firm-level bond priority portfolio returns by value-weighting bonds issued by the same firms and also require that firms have bonds with at least two distinct priorities with remaining maturities longer than three years, which shrinks our sample size to 258,387 observations.

Table 2 provides a preview of the results to come in later analyses. Consistent with the theoretical predictions, across all four ranges that contain levered firms, the durations decrease from the higher priority bonds to the lower priority bonds and finally to equity. For example, for the lowest leverage quintile, the duration for 5-year CMT yield changes decreases from 2.9 to 2.2 to -1.70, while for the highest leverage quintile, the duration similarly decreases from 0.84 to 0.60 to -2.10. These results also mostly confirm other implications of our theoretical framework.[20]

First, equity has negative duration across all leverage quintiles. This finding at the firm level is not discussed in the existing literature yet follows directly from equity's location in capital structure priority. 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, the bonds have declining duration as the market value of assets decline relative to the face value of the debt. For example, the duration of senior declines from 2.90 to 2.49, 2.13 and 0.84, and the duration of junior debt declines from 2.22 to 2.13, 1.48 and 0.60 as leverage increases. Finally, as explained in Section III.A, equity's duration is related to both the asset duration of the firm and the firm's leverage. Asset duration has an inverted U-shape across leverage quintiles, and so too does equity duration. This shows the importance of taking into account the characteristics of the assets.

[20] Note that these durations are calculated relative to the 5-year CMT yield. Our theoretical analysis focuses on durations relative to the instantaneous yield. In a 1-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).

One way to take out the effect of asset returns is to compare returns across securities of the same firm, thus somewhat mitigating changes due to variation in the value of the firm's assets. Of course, the control will only be partial due to the securities' different deltas with respect to the assets. Table 3 estimates the interest rate sensitivity of security returns within each firm's capital structure using a difference-in-difference type approach to the estimation of equation (8). In other words, to adjust for each firm's overall sensitivity to interest rates and other things such as the asset return misspecification above, we look at the estimates from the regression:

$$R_{t+1}^{m} - R_{t+1}^{n} = \alpha + \beta(-\Delta i_{t+1}) + \gamma(\tau_t^m - \tau_t^n)(-\Delta i_{t+1}) + \epsilon_{t+1}, \tag{9}$$

where $R_{t+1}^{m} - R_{t+1}^{n}$ is the return difference between two securities issued by the same firm, with the security m being lower priority than security n, and $\tau_t^m - \tau_t^n$ is the difference in time-to-maturity between 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 β, i.e., does duration differ between the two securities of different priority and in what direction does this effect go. We include the interaction term with the difference in time-to-maturity to control for the effect of maturity on bond duration. We require firms to have at least two securities with different priorities to be included in the sample for this regression analysis.

Table 3 confirms the main implications of our theoretical framework described in Section II. Since the β coefficient estimates in equation (9) are negative (and strongly statistically significant), higher priority debt issues within the firm have a higher duration. Controlling for time to maturity differences barely changes this coefficient estimate, although γ is positive indicating that longer maturity bonds have the expected higher duration. Most important, Table 3 shows that equity returns have a lower duration than the fixed rate bonds within the firm. The magnitude of this effect is large, i.e., -1.54, consistent with equity being short the bond market due to its priority location.

C. Asset Return-Adjusted Estimates of Durations of Corporate Securities

Tables 2 and 3 provide general support for the testable implications discussed in Section II. In this subsection, we directly estimate equation (7). Table 4A and 4B report pooled estimation results respectively for the interest rate sensitivity of bond returns and equity returns, using the full sample of securities available in our data. The theory says that priority and leverage should matter, in particular, $\beta_t < 0$ for equities, $\beta_t > 0$ for senior debt, $\beta_2 > 0$, and $\beta_1 < 0$ in equation (7). Table 4 confirms these predictions.

Consider the second column in which we ignore the return on assets. On the bond side, not surprisingly, the duration of bonds is positive and increasing with maturity ($\beta_0 > 0$, the marginal effect being 0.21τ). Most important, higher priority bonds have higher duration ($\beta_2 > 0$, the marginal effect being $0.11P_t\tau$). 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. Moreover, the greater the leverage, the lower the duration becomes ($\beta_1 < 0$, with the effect $-0.05L_t\tau$). 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 standard structural models that ignore the priority structure of debt do not capture the interest rate sensitivity of corporate bonds.

On the equity side, column 1 of Table 4B (in which we ignore the return on assets) appears to present a conundrum. Both the duration coefficient and the leverage coefficient are positive, the opposite of the implications of the theoretical framework presented in Section III and the preliminary duration estimates in Section IV.B. Two observations are in order. First, and somewhat minor, neither of the coefficients is statistically significant. Second, and more important, the regressions do 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 3 of Table 4A and column 2 of Table 4B present the results for the estimation of equation (7), controlling for asset returns. As expected, the returns on both bonds and stocks load positively on asset returns.[21] More interesting is the effect of including asset returns on the duration

[21] 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.

estimates. First, consider equity returns. When asset returns are included in the regression (i.e., column 2 of Panel B), for 5-year CMT yield changes, the duration coefficient becomes negative and statistically significant at -0.67 (compared to 0.15 in column 1). A similar result holds for the impact of leverage on duration, with a switch from 0.00 to -0.20 once asset returns are accounted for. Thus, the results strongly support the priority theory of the capital structure for the duration of equity, i.e., equity duration is negative and more so for highly levered firms. With respect to bonds, the new coefficients on interest rate changes given in column 3 of Table 4A differ little when asset returns are included in the regression.

As discussed in Section II, Duffee (1998) and Schaefer and Strebulaev (2008) document declining interest rate sensitivity as credit ratings deteriorate. Because credit rating agencies, to some degree, use inputs such as leverage, priority, volatility, bond covenants, etc., it is a worthwhile question therefore to consider how the results of Table 4A change as we add credit ratings to the regression analysis. We incorporate credit ratings in two ways. First, in column 4, we add both dummy variables for ratings and these dummy variables multiplied by $\tau\Delta i$. In column 5, we use the same fixed effects but drop leverage and priority, and in column 7 we replace asset returns by equity returns to mimic Schaefer and Strebulaev (2018). In columns 6 and 8, rather than use dummy variables multiplied by $\tau\Delta i$, we parameterize ratings and use the variable $Ratings \times \tau\Delta i$.[22] Column 8 again substitutes equity returns for asset returns.

Several observations are in order. First, and most important, adding credit ratings to the regression (column 4 versus column 3) provides no increase in explanatory power, i.e., the R^2's are essentially the same. Second, with respect to the coefficients, the coefficient on priority barely moves from 0.098 to 0.099. Interestingly, the coefficient on priority times leverage increases from 0.028 to 0.043, but the coefficient on leverage drops from -0.061 to 0.002, becoming insignificant. Third, when priority and leverage are dropped from the regression (column 4 to 5), the R^2 falls from 25.4% to 20.6%, implying credit ratings are not sufficient for describing interest rate sensitivity. The R^2 declines even further when equity returns replace asset returns in column 7 (as in Schaefer and Strebulaev (2008)), i.e., 20.6% to 17.3%. Fourth, the different specification of credit ratings does not seem important to the regression model as columns 5 and 7 give similar results to columns

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

6 and 8. As a whole, these results provide evidence that the effect of capital structure priority is significant.

As a final comment on the Schaefer and Strebulaev (2008) specification, note that in terms of interest rate sensitivity for corporate bonds being too low, one possible explanation is misspecification of the model as evidenced by the drop in R^2 from 25.4% to 17.3% (our model in column 4 versus theirs in column 7). Comparing the estimates from these models provides some insight into this question. Specifically, assuming median leverage and priority levels in column (4), the coefficient on $\tau\Delta i$ is 0.350, 0.369, 0.370, 0.352, 0.314, 0.184 and 0.028 respectively for AAA, AA, A, BBB, BB, B and CCC bond ratings compared to 0.347, 0.354, 0.341, 0.324, 0.257, 0.142 and -0.028 for Schaefer and Strebulaev's (2008) specification. For the high yield bonds at least, i.e., BB and B, the interest rate sensitivity is 22.2% and 29.6% higher in our model.

Note that Table 4 provides pooled regression results for the duration of corporate securities across all firms and their respective asset durations. A novel implication from Section III.A and Figure 1 is that, for large positive duration assets, the above theoretical results reverse with $\beta_t > 0$ for equities, monotonically decreasing in priority (i.e., $\beta_2 < 0$), and increasing in leverage (i.e., $\beta_1 > 0$). To test this implication, we break the sample into terciles based on asset duration and rerun the standard regression model of the paper:

$$R_{t+1} = \alpha + \beta_t \tau_t (\Delta i_{t+1}) + \epsilon_{t+1}$$

$$\beta_t = \beta_0 + \beta_1 L_t + \beta_2 P_t + \beta_3 L_t P_t + \beta_4 Z_t \quad (10)$$

Table 5 reports the results. Consider the tercile of firms with the highest asset durations. Consistent with the theoretical predictions, equity now has the highest, rather than lowest, duration across the firm's capital structure. However, the results are mixed for bonds. While the estimate of the priority coefficient β_2 is still positive, the estimate is effectively zero and no longer significantly positive. Nevertheless, an important confirmation of the theory is that, while the duration of corporate securities decrease with leverage for most firms, these durations increase with leverage for firms with large, positive asset duration. Table 5 shows that this is the case. For example, for bonds, the estimates of β_1 on $(L_t \tau)\Delta i_{t+1}$ across the low to high asset duration firms are respectively -0.327, -0.099 and 0.061, and, for stocks, -2.467, -0.587 and 1.029.

In the analysis discussed above, our 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 more subject to default risk. As a robustness check, we exclude floating rate bonds in constructing the priority variable. In results provided in the Online Appendix, we find qualitatively similar results when excluding floating rate bonds, showing that the main results in Tables 4 and 5 are robust.

V. The Interest Sensitivity of Aggregate Portfolio Returns

What implications does our firm-by-firm analysis have for the interest rate sensitivity of aggregate portfolio returns? Because portfolio asset returns are weighted averages of individual asset returns, portfolio leverage and priority levels will also be weighted averages, and these weighted averages will help determine the interest rate sensitivity of the portfolio asset returns. We consider two applications in this section. The first analyzes the much studied correlation patterns between equity portfolio returns, corporate bond portfolio returns and government bonds. The second investigates a number of issues relevant to stock and bond factor models and whether our insights on capital structure priority has anything to add to these models. We look at three examples: (i) popular bond factors, the term premium and default premium, (ii) measuring systematic bond risk, in this case, bond betas from a market model regression, and (iii) jointly estimating time-variation in expected stock and bond returns.

A. The Correlation of Asset Index Returns and Government Bonds

There is a considerable literature documenting the comovements of stock returns 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 either on shocks to the real economy and inflation or on shocks to liquidity, uncertainty, or aggregate behavioral phenomena. The surprising finding is that the driving force behind this time-varying correlation is not macroeconomic fundamentals, but the components related to liquidity and flights to safety.

In contrast, the theory of Section III and the empirical analysis of Section IV show the importance of (i) the relative value of the firm's assets to its debt obligations, and (ii) the priority of the security within the firm's capital structure in determining interest rate sensitivity. Because stock and corporate bond index returns are simply returns on portfolios of individual securities, the relevance of priority and leverage for explaining the interest rate sensitivities of individual securities should aggregate up to the index level. To see this, 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 has in the index. Using equation (7) to substitute in for the returns, and assuming that the underlying assets of the firms have zero duration, the index is equal-weighted, and time to maturity is uncorrelated with the other quantities, the correlation between the index return and interest rate changes can be written as:

$$corr\left(R_{p,t+1}, -\Delta i_{t+1}\right) = \left[\left(\beta_0 + \beta_1 \overline{L_{it}} + \beta_2 \overline{P_{it}} + \beta_3 \overline{L_{it} P_{it}} + \beta_4 \overline{Z_{it}}\right)\overline{\tau_{it}}\right] \frac{\sigma(\Delta i_{t+1})}{\sigma(R_{p,t+1})} \qquad (11)$$

where $\overline{L_{it}}$, $\overline{P_{it}}$, $\overline{L_{it} P_{it}}$, and $\overline{\tau_{it}}$ are respectively the average values of leverage, priority, leverage times priority, and maturity of the securities within the index.[23]

Clearly, the average leverage of the firms included in the index and the average priority of the securities within the index play a role in describing the correlation between the index return and interest rate changes. For example, ceteris paribus, given that $\beta_1 < 0$, equation (11) shows that

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

higher average firm leverage pushes the correlation between index returns and government bond returns more negative. Since periods of high leverage are often associated with large drops in asset value, negative aggregate correlations can result even if interest rates are unrelated to aggregate asset values. In addition, equation (11) shows that because $\beta_2 > 0$, the correlation of the index return with the government bond return is generally more positive 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 often in the middle of the capital structure. Thus, the literature ignores the average leverage of the firms in the index and the average priority of the securities in the index within these firms. It is interesting to see how much of the time-variation in stock and bond return comovements can be explained by this fact alone.

i. The Correlation between Equity Index Returns and Government Bonds

Figure 2 graphs the rolling estimate of an aggregate leverage measure and the correlation between the returns on equity and Treasury bonds over the period 1985 to 2012. The correlation is estimated using a 36-month rolling window of index returns and five-year Treasury returns. We take the value-weighted average of equity returns on our sample of firms to construct the index returns. The figure produces the well-known stylized fact that the correlation switches signs from positive to negative during the early 2000s. This dynamic has been a focal point of the aforementioned literature.

Not addressed in this literature, but key to the thesis of this paper, is that, consistent with firm-level evidence and with the theory of contingent claims pricing of corporate securities, there appears to be a close relation between the comovements of stock returns and government bond returns and the degree of leverage in the economy. The correlation is 0.54 between the inverse of aggregate leverage of the portfolio of firms and the comovements of equity and government bond returns. These findings suggest that any theoretical model developed to explain the comovement of equity returns and interest rate changes should include the fact that equity is effectively short fixed rate debt.

An interesting observation is that the correlation between the returns on the equity index and government bonds shifted from positive to negative around 2000, which also coincides with a significant increase and somewhat permanent shift in the average leverage of firms. That said, leverage alone cannot explain the level of the correlation. Leverage was also high in the late 1980s and early 1990s, yet the estimated correlation between equities and government bonds was positive.

As described in Section IV.C, one of the difficulties in relating stock and bond returns to interest rate changes via leverage and priority is that the value of the underlying assets of the firm may be related to interest rates. Therefore, in Figure 2, we also employ asset-neutral equity returns by adjusting the return on the equity index by the return on the assets underlying the index. That is, we repeat the above exercise using the return on the index in excess of the estimated component of this return that is attributable directly to the asset return, $R^e_{p,t+1} \equiv \Sigma_i w_{i,t}\left(R_{i,t+1} - \theta_{i,t} RA_{i,t+1}\right)$. Thus, in theory, by removing the sensitivity to the return on the underlying assets, we will be better able to isolate the effect of leverage on the correlation between the returns on equity and government bonds.

Some interesting insights emerge from examining asset-neutral duration. First, over the 30-year period, the estimated correlation between aggregate stock returns and government bond returns is always negative once adjusting for asset returns. This estimate of negative duration of aggregate excess stock returns is broadly consistent with the theory of Section III and firm level evidence of Section IV. Second, 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 (such as -0.5 and below), especially in the latter part of the sample, are significantly different from zero. Third, the correlation between Treasury bond returns and equity returns exceeds the correlation between Treasury bonds and asset-adjusted equity returns throughout the entire period. Finally, Figure 2 shows that the time-series pattern of the rolling correlations matches the pattern in the average leverage, with an even higher correlation of 0.62.

Recall that previous empirical work documents comovements between the stock market's return and government bond returns ignoring measures of aggregate leverage. As one such example, Baele, Bekaert, and Inghelbrecht (2010) use a dynamic factor model to explore the determinants of the correlation between equity and bond returns. They use a variety of macroeconomic factors, including interest rates, inflation and the output gap among others, plus measures of changing risk aversion and proxies for liquidity. Their basic finding is that macroeconomic factors play little role in explaining equity and bond comovements and that "non-fundamental" factors like liquidity are more important.

Working off Figure 2, 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 bond returns on measures of market illiquidity, uncertainty, and risk premiums in addition to aggregate leverage.[24] Aggregate leverage is calculated as the ratio of the weighted value of aggregate book debt to market assets. All the explanatory variables are standardized to allow easier comparisons of economic significance. The sample starts in 1990 due to the availability of VIX.

Table 6 reports the results. Consider the regressions underlying columns (1) and (5). Respectively, the rolling correlation between the returns on the equity index and Treasuries (and between the asset duration-neutral equity index and Treasuries) are regressed on the corresponding leverage of the index. Consistent with the theoretical framework of Section III and Figure 2, the coefficient on leverage is negative and statistically significant with respective adjusted R^2s of 27% and 39%.[25] For example, a one standard deviation increase in leverage decreases the bond-equity correlation by 0.20. When controls for either asset volatility (see equation (11) and the Online Appendix) or Baele, Bekaert and Inghelbrecht's (2010) set of liquidity and macro variables are included, the leverage variable is similarly negative and statistically significant (-0.12 when all the control variables are present). The statistical results of Table 6 strongly support the graphical

[24] In terms of the explanatory variables, the stock market illiquidity measure is the market capitalization-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).

[25] 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 estimators are adjusted for this serial dependence, the R^2s will also have a bias (e.g., Boudoukh, Richardson and Whitelaw (2008)). Because there are effectively many less 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.

conclusions of Figure 2 that firm leverage plays an important role in explaining the correlation between the returns on aggregate equity indices and government bonds.

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. Adjusting for leverage and asset volatility, the adjusted R^2 jumps from 27% to 55% when we include liquidity controls in Column 3 and from 39% 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. Interestingly, as Baele, Bekaert and Inghelbrecht (2010) also document, macro-related fundamentals do not seem to be related to the aggregate equity-government bond correlation. Indeed, the adjusted R^2s either stay the same or drop in the relevant Columns 4 and 8 of Table 6.

Interpreting the results in Figure 2 and Table 6 is potentially problematic due to the small number of nonoverlapping observations. However, by utilizing information in the cross-section about the correlation between stocks and interest rates, we gain additional (albeit noisy) observations. 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. Figure 3 provides the time-series of this fixed effect and corresponding confidence bands (the gray line). This fixed effect can be viewed as the average correlation between the returns on individual equities and Treasury bonds, adjusted for asset returns and leverage. Figure 3 also provides estimates of the time fixed effect from the regression without any controls (the black line).

There are some key takeaways from Figure 3. First, note that the correlation estimates in general are tighter than those in Figure 2. This tighter correlation may be due to less measurement error in the estimates using the full cross-section. Alternatively, correlations at the aggregate level may also have higher absolute levels because of little idiosyncratic volatility, i.e., a diversification effect. Second, and importantly, Figure 3 confirms the main finding of Figure 2, namely that asset duration and leverage are key determinants of the correlation between stock returns and interest rates. That is, the gray line (with the controls) shows much less variation through time, implying that much of the time-variation is due to these controls. Third, that said, there is still a swing from positive to negative in the correlation of the returns on equities and government bonds even with the controls included. Consistent with conclusions drawn from Table 6, this result suggests that some other factors (like liquidity) must be partially at play.

ii. The Correlation between Corporate Bond Index and Government Bond Returns

Overall, the results in Section V.A.i above indicate that financial leverage is an important variable for explaining the correlation between the returns on equity indices and government bonds. Equation (11) implies that, along with a measure of the priority level of a corporate bond portfolio, similar results should carry through for the correlation between the returns on corporate bond indices and government bonds.

In order to investigate this correlation, we construct two corporate bond portfolios from the same subset of firms used in our prior analyses that differ only by the priority of the underlying bonds. 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 both cases considering only bonds without embedded option features. We focus on high yield firms and the post-1992 period to ensure that there at least 30 bonds in each portfolio. The portfolios are equal-weighted, and the two portfolios have the same number of bonds drawn from the same firms.

Figure 4 graphs the number of bonds in the portfolios and their average ratings through time. 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. For the first several years through the early 2000s, the average credit ratings of the bonds are relatively high with only a small differential between them. 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 2000 suggests the firms have an increasing cross-section of bonds with different priorities.

Figure 5 provides a graph similar to that of Figure 2, but now for the two portfolios of corporate bond securities of the same firms. By construction, the portfolios are governed by the same average leverage but have quite different priority structure. At the aggregate level, under certain assumptions, one would expect the interest rate sensitivity to be declining in priority, and, holding the sensitivity of asset returns to interest rates constant, would move from the positive to negative as we move from high priority debt to equity.

Figure 5 displays several key elements of the theory relating corporate bond returns to interest rates. Consider first the correlation of the returns on the senior high yield bonds with the government bond. As expected, the correlations are quite different between good and bad economic states; the correlations drop substantially during the recession periods of 2001 and 2007-2009. More interesting, the correlations of the senior portfolio with government bonds are higher everywhere than those of the junior bond portfolio. This result is expected based on the contingent claim pricing theory of Section III and firm-level evidence reported in Section IV. The impact of leverage is also visible in Figure 5. Post 2000, the level of leverage closely tracks the corporate bond-government bond correlation, and especially so for the junior bond portfolio. As leverage increases (i.e., the ratio of market value of assets to book debt (MABD) 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 has its lowest – in fact, negative – correlation with government bonds. Finally, when we adjust the bond portfolios for their sensitivity to the underlying return on the index of assets, the results still carry through accordingly.

Table 7 provides results of the regression counterpart to Figure 5. The two main findings from Table 7 are (i) leverage matters for explaining the correlation between corporate bonds and government bonds, and (ii) the correlation is higher for senior than junior debt. With respect to (i), the coefficient on leverage (1/MABD) in column 1 of Table 7 is -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 average leverage of the portfolio leads to a 16% and 29% drop in the correlation. As the theory suggests, higher leverage leads to lower duration for all corporate bonds and the magnitude is greatest for bonds of lower priority. With respect to (ii), the constants in column (1) represent the average correlation between senior/junior bonds and government bonds over the sample period. Consistent with the theory, the senior bond portfolio has higher correlation than the junior bond portfolio, 0.76 versus 0.57. The results are robust to adjusting for the sensitivity of the bonds to asset returns (columns 5-8 of Table 7).

These results for the duration of corporate bonds of different priority are potentially important. It is quite standard in the literature (e.g., Fama and French (1989, 1993)) to argue that the appropriate default premium should be the yield or return spread between high-yield corporate debt and AAA-rated corporate debt, presumably to isolate the default risk from the interest rate risk. However, changes in yields of low priority corporate debt have little relation to changes in interest rates. The fact that this interest rate sensitivity varies greatly with leverage further complicates the matter. Therefore, the default premium may in fact be comingling the two risk components with changing weights through time. We address this issue in Section V.B.i below.

iii. The Correlation between Corporate Bond Index and Equity Index Returns

So far, Section V has focused on the correlation between corporate security index returns and government bond returns. The theory also has implications for the correlations between index returns on these corporate securities. While there is an existing literature that explores the relationship between equity index and corporate bond returns (e.g., Blume, Keim and Patel (1991) and Cornell and Green (1991)), there is no research that focuses in particular on capital structure priority. Aggregating up the individual equity and bond data, as in Sections V.A.i and V.A.ii, we construct equity indices and high yield corporate bond indices of different priorities using the same firms over the period 1992 to 2012.

Figure 6 provides a graph of the rolling estimate of leverage and the correlation between the returns on an equity index and the high yield corporate bond indices. Consistent with the importance of capital structure priority, the correlation between equity and junior debt is higher than senior debt in almost every period. Moreover, the swing in correlation appears to coincide with movements in leverage. Table 8 provides the associated statistics. The average correlation of equity and junior debt is 0.46 versus 0.33 for senior debt (e.g., see column 1 of Table 8). Leverage is significantly related to equity's correlation with junior debt (e.g., a one standard deviation increase in leverage increases correlation by 0.077) though not with senior debt.

B. Implications for Factor Models

In this subsection, we exploit the structural relationship between stocks and bonds based on their capital structure priority to document new, and reinterpret some existing, empirical results with respect to stock and bond factor models. In particular, we explore three areas: (i) interpreting the commonly used term premium and default premium risk factors, (ii) measuring the betas of corporate bonds, and (iii) developing joint models for time-varying expected returns of bonds and stocks. With respect to these topics in the literature, our analysis is novel to the extent no attention has been given to the impact of the relative location of stocks and bonds within a firm's capital structure.

i. The Term Premium and Default Risk Factors

Researchers have tried to relate stock and bond returns to aggregate bond factors unconditionally. For example, consider the popular Fama and French (1993) regression framework:

$$R_{t,t+1}^{B_i} - R_t^F = \alpha + \beta_1 (R_{t,t+1}^{LTG} - R_t^F) + \beta_2 (R_{t,t+1}^{CORP} - R_{t,t+1}^{LTG}) + \varepsilon_{t,t+1}, \tag{12}$$

where $R_{t,t+1}^{LTG} - R_t^F$ is the excess return on a long-term government bond (term factor) and $R_{t,t+1}^{CORP} - R_{t,t+1}^{LTG}$ is the return on corporate debt minus the return on a long-term government bond (default factor). The purpose of this specification is to decompose return premiums into components due to the term premium (interest rate risk) and the default premium (default risk). Depending on the priority structure of the underlying corporate debt, equation (2) and Figure 1 show that this approach may be misleading. It is quite possible that $R_{t,t+1}^{CORP}$ includes firms with debt of different priorities, which will affect the dependence of these debt returns on interest rates. If the sensitivity of $R_{t,t+1}^{CORP}$ to interest rates differs from that of $R_{t,t+1}^{LTG}$, then the difference picks up both interest rate risk and default risk. In the extreme case where corporate debt is insensitive to interest rates, the coefficient on the term factor variable will equal the sum of the coefficients in the regression that correctly isolates default and term risk. In other words, because the mismeasured default factor loads negatively on the term factor, the coefficient on this latter 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 issue with the specification in equation (12), we run two sets of regressions of returns on different portfolios of bonds and equities sorted by their firm ratings (i.e., AAA, AA, A, BBB, BB and B) against the five Fama and French (1993) factors (i.e., three equity factors (market, SMB, and HML) and two bond factors (TERM and DEF)). The sets of regressions differ by their definition of DEF, one using Fama and French's (1993) definition in equation (12) above, and the other recognizing that the duration of corporate bonds differs from that of government bonds. In particular, denote the return spread between aggregate corporate bonds and long-term government bonds similar to Fama and French (1993) as DEF1. The return spread that considers the duration of corporate bonds is denoted as DEF2, which is the difference between returns on aggregate corporate bonds and a short-term government bond (five-year maturity). The sample period is from 1990 to 2012 because of the availability of returns on high-yield bond indices.

Table 9, Panels A and B provide the regression results for equation (12) for six issuer-level ratings portfolios, using the two default factors, DEF1 and DEF2. Since corporate bonds have a much shorter duration than long-term Treasury bonds, DEF1 captures not only the default component of equity and bond returns, but also the negative of the term factor (TERM). Thus, there will be an upward bias in the coefficient on TERM and possibly also a bias in the coefficient on DEF1. In contrast, DEF2 is a cleaner measure of the default factor than DEF1, and the coefficients in this regression should present a more accurate picture of loadings on default and interest rate risk.

For both equity and bond portfolio returns, the loadings on TERM tend to be larger in Panel A, especially among bond portfolios.[26] For example, the coefficients in Panel A for the BB and B bonds are 0.96 and 1.00, versus 0.12 and 0.03 in Panel B. Thus, it is clear that the misspecified regression vastly overstates the effect of interest rate risk on return premiums for high-yield bonds. For high grade bond returns, the loadings on DEF1 are significantly larger than those on DEF2 (0.44, 0.49, and 0.62 versus 0.31, 0.31 and 0.45, for the AAA, AA and A indexes), indicating that the typical approach, following Fama and French (1993), erroneously exaggerates the perceived degree of default risk among investment grade bonds.

[26] Panel C provides the differences in coefficients and test statistics on *Term* and *Def* between Panel A and Panel B from GMM estimation with an identity weighting matrix with a Bartlett kernel of 4 lags.

ii. The Betas of Corporate Bonds

There is an extensive literature in finance that tries to measure the beta of corporate bond returns. Using a standard market model motivated by the CAPM, Alexander (1980) and Chang and Huang (1990), among others, have run typical regressions of excess corporate bond returns on aggregate equity market returns and found the betas to be quite low. Alternatively, using Merton (1974) as motivation, a number of authors have run similar regressions on excess long-term government bond returns and the spread between investment-grade corporate bond and long-term government bond returns. Depending on the formulation, the success of these models is mixed (see, for example, Fama and French (1993), Elton, Gruber, Agrawal, and Mann (2001), Gebhardt, Hvidkjaer, and Swaminathan (2005), and Bao, Pan, and Wang (2011)).

Consider the CAPM regression. Once one recognizes the priority tranches of each firm, it is not surprising that the typical CAPM regression produces counter-intuitive results. Rewriting the aggregate market return in terms of the underlying assets and debt,

$$\begin{aligned} R^{B_i}_{t,t+1} - R^F_t &= \alpha + \beta(R^M_{t,t+1} - R^F_t) + \varepsilon_{t,t+1} \\ &= \alpha + \beta((R^{V_M}_{t,t+1} - R^F_t) + \frac{D_{Mt}}{E_t}(R^{V_M}_{t,t+1} - R^{D_M}_{t,t+1})) + \varepsilon_{t,t+1} \end{aligned} \tag{13}$$

the corporate bond's beta includes two terms, $cov(R^{B_i}_{t,t+1}, R^{V_M}_{t,t+1})$ and $\text{cov}(R^{B_i}_{t,t+1}, \frac{D_{Mt}}{E_t}(R^{V_M}_{t,t+1} - R^{D_M}_{t,t+1}))$.

The first term is the covariance of a firm's bond return of a particular priority (or of a portfolio of bond returns) with the aggregate return on the assets of all firms. This is what we would normally consider to be the typical CAPM framework. If a firm's debt value (i.e., default probability) does not vary much with the aggregate economy, then the beta would typically be close to zero. This is not necessarily true in equation (13). To the extent that aggregate corporate debt in the economy moves with interest rates, the estimated beta from equation (13) for relatively safe firm debt will tend to be negative as $\text{cov}(R^{B_i}_{t,t+1}, \frac{D_{Mt}}{E_t}(R^{V_M}_{t,t+1} - R^{D_M}_{t,t+1})) < 0$. 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 priority of its claim), then the estimated beta from equation (13) will be positive yet scaled down by $\frac{V_{Mt}}{E_t}$. That said, it should be clear that the β estimate will depend mostly on the priority of the bond for the firm in question. Equation (13) also makes obvious the fact that these relations are time-varying if for no other reason than their dependence on $\frac{V_{Mt}}{E_t}$, which varies through time.

Table 10 reports results for the typical CAPM regression for corporate bonds using the aggregate market return. We perform these regressions for portfolios of bonds with different maturities, different capital structure priorities, and different levels of credit risk. Consistent with existing evidence, all the coefficients on investment grade bonds are small and close to zero. This result implies that investment grade corporate bond returns have low risk premiums, giving credence to the fact that the yield spreads on corporate bonds seem too high given their low default probability. The coefficients on high yield bonds are higher, but arguably lower than one might expect given the close relation between low priority, risky debt and equity.

However, the discussion above suggests that the use of the aggregate equity return in the CAPM regression might be misleading given the fact that equity claims are long the assets and short fixed rate debt. We rerun regression equation (13) in two different ways. First, we separate the aggregate equity return into the asset return and a remainder term which captures the short debt component. Second, we use the return on aggregate assets as the factor.

With respect to the former, the results are startling. The beta coefficient on the asset return is considerably higher while the coefficient on the remainder term is negative. For example, consider the medium-term maturity (5-8 and 8-15 years), high priority, investment grade portfolios. The beta coefficients go from 0.11 and 0.15 to 0.53 and 0.69, respectively when we break equity into its relevant components. The remainder term has a coefficient of -0.90 and -1.15. Thus, the low beta of corporate bonds is not because the "true" asset beta is low but because its positive risk premium is offset by its short position in the bond market.

With respect to the latter, we document the betas of the various bonds against the aggregate return on assets. The results are less dramatic but still point in the same direction. For all bonds, irrespective of maturity, priority, or credit risk, the beta is higher using asset returns than market returns. For example, consider the medium-term maturity (5-8 and 8-15 years), high priority, investment grade portfolios. The beta coefficients go from 0.11 and 0.15 to 0.18 and 0.25, respectively. Both this result and the one above provide some evidence that corporate bonds are riskier than existing results might suggest.

iii. Time Variation in Expected Returns

In his AFA presidential address, Cochrane (2011) states that discount rate variation is the central question of asset pricing research. He argues that understanding the multivariate factor structure of expected returns on different asset classes, such as stocks and bonds, is key. He then goes on to describe various candidate models from macroeconomics and those based on standard finance theory, market frictions and behavioral economics. However, he does not discuss the potential importance of leverage and the structural link between stocks and bonds described in this paper. In fact, Cochrane (2011) frames his question by writing a joint expression for stock and bond returns as

$$\begin{aligned} R_{E:t,t+1} &= \alpha_E + \beta_{1e} dp_t + \beta_{2e} ys_t + \beta_{ze}' z_t + \varepsilon_{E:t,t+1} \\ R_{B:t,t+1} &= \alpha_B + \beta_{1b} dp_t + \beta_{2b} ys_t + \beta_{zb}' z_t + \varepsilon_{B:t,t+1} \end{aligned} \quad (14)$$

where $R_{E:t,t+1}$ is the return on stocks, $R_{B:t,t+1}$ is the return on bonds, dp_t is the dividend yield on stocks (or more broadly equity-like factors), ys_t is the term spread on bonds (or more broadly bond-like factors), and z_t are additional predictor variables. He suggests that the finance field needs to better understand the coefficients β_{2e}, β_{ze}, β_{1b}, and β_{zb}.

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. That said, while these papers identify the likely predictive variables, Cochrane (2011) correctly points out that there has not been much progress in understanding the joint determinants of time-varying expected returns on stocks and bonds. To the extent that these discount rates for stocks and bonds are determined by a single stochastic discount factor, there would be considerable benefit in advancing the literature in this direction.

However, it is clear from Cochrane's discussion and, for that matter, much of the aforementioned literature that researchers consider a portfolio of firm equity returns and a portfolio of firm asset returns as interchangeable. Of course, this treatment ignores the levered nature of equity returns, namely that stock returns are long asset returns and short bond returns. In other words, equation (14) should ideally be represented in the following form:

$$\begin{aligned} \tfrac{A_t}{E_T} R_{A:t,t+1} - \tfrac{D_t}{E_t} R_{B:t,t+1} &= \alpha_E + \beta_{1e} dp_t + \beta_{2e} ys_t + \beta_{ze}^{'} \, z_t + \varepsilon_{E:t,t+1} \\ R_{B:t,t+1} &= \alpha_B + \beta_{1b} dp_t + \beta_{2b} ys_t + \beta_{zb}^{'} z_t + \varepsilon_{B:t,t+1} \end{aligned} \tag{15}$$

Table 11 documents results from the estimation of regression system (14 and 15), plus an additional regression with asset returns, using the following three predictors: (i) the dividend yield, dp_t, of Fama and French (1988), (ii) the term spread, ys_t, i.e., the difference between the 10-year, constant maturity Treasury yield and the 3-month T-bill rate, and (iii) the yield spread between high yield corporate bonds and T-bills, denoted $z_t \equiv def_t$. We run the regressions using the firms in the sample underlying the results reported in Table 9.

The economic magnitudes of the coefficients in Table 11 highlight the intuition outlined above, although some of the coefficient estimates are statistically insignificant due to our relatively short sample period from 1991 to 2012. The predictability of the dividend yield is strong for equity returns. This result largely stems from asset returns, i.e., asset returns also exhibit strong predictability. In contrast, the dividend yield predicts bond returns only weakly. Similarly, the negative coefficient on the term spread for equity returns, albeit statistically insignificant, comes mainly from asset returns (i.e., $\tfrac{A}{E} R_{A:t,t+1}$).

On the other hand, the estimated coefficient on the default spread is due, at least in part, to the short position in bond returns. Corporate bond returns load positively and with statistical significance at the 5% level on this spread, which is not surprising. Consequently, since equity holders are effectively short this bond return, the negative coefficient on this spread in the equity equation reflects this short position.

Thus, the above analysis shows that an understanding of the discount factors for stocks and bonds, i.e., the coefficients in equations (14) and (15), 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.

Even if the researcher uses this insight, there is still the question of how to choose and interpret the predictive variables. For example, in Table 11 we used two common predictive variables, namely the term premium – the yield spread between long-term government and short-term government bonds – and the default premium – the yield spread between high-yield corporate debt and T-bills (see, for example, Keim and Stambaugh (1986)). Fama and French (1989) argue that the appropriate default premium should be the yield spread between high-yield corporate debt and AAA-rated corporate debt, presumably to isolate the default risk from the interest rate risk. However, as pointed out in Section V.B.i, changes in yields of low priority corporate debt have little relation to changes in interest rates. Therefore, the default premium may in fact be comingling the two risk components. A comparison of the two seminal papers in the area – Keim and Stambaugh (1986) and Fama and French (1993) – shows different results. This is likely due to different definitions of the default premium. The former paper uses short-term bond yields while the latter uses long-term bond yields as the benchmark for the default premium.

Table 12 reports results using these two different measures and shows, in fact, that there is a significant difference in the economic magnitudes of the coefficients. We use *def(KS)*, the yield difference between high yield bonds and 3-month T-bills, and *def(FF)*, the yield difference between high yield and AAA-rated corporate bonds. Interpreted in the context of our results above, *def(KS)* captures time-varying expected returns driven mainly by the default risk of bonds, whereas *def(FF)* is a mixed measure that captures both the default and term premium components. The empirical results are consistent with this intuition. In the regression using the Keim-Stambaugh style variable, *def(KS)*, 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 the 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 may erroneously suggest larger term and default risk premiums than actually exist. Again, 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), and these differences illustrate the need to be careful when analyzing aggregate equity and bond returns.

V. 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 the firm in analyzing this relation. The basic message of this paper is that capital structure priority matters for determining the interest rate sensitivity of corporate securities. Specifically, we appeal to contingent claim asset pricing to exploit capital structure priority to better understand the relation between corporate security returns and interest rate changes. In particular, we show theoretically and, using a novel dataset, confirm empirically that lower priority securities in the capital structure, such as subordinated or distressed debt and equity, have low or even negative duration. This result obtains because the lower priority securities are effectively short higher priority fixed rate debt, i.e., short the bond market. Using these results, we investigate and reinterpret existing results in the literature that focus on (i) time-varying correlations between returns on the aggregate stock, corporate bond and government bond markets, and (ii) factor models for returns on stocks and bonds. The bottom line from our analysis is that researchers need to rethink the way they use aggregate stock and bond data in light of the priority structure of firms.

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Appendix

Derivations of Durations

The modified duration of the firm's assets is

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

For the senior bond, modified duration is

$$\begin{aligned}\mathrm{Dur}(D_s) &\equiv -\frac{\mathrm{cov}\left(\frac{dD_s}{D_s}, dr\right)}{\mathrm{var}(dr)} \\ &= -\frac{\mathrm{cov}\left(\frac{\partial D_s}{\partial V}\frac{V}{D_s}\sigma_V dZ + \frac{\partial D_s}{\partial r}\frac{1}{D_s} vdW, vdW\right)}{\mathrm{var}(vdW)}, \\ &= -\frac{\partial D_s}{\partial V}\frac{V}{D_s}\frac{\rho\sigma_V}{v} - \frac{\partial D_s}{\partial r}\frac{1}{D_s}\end{aligned}$$

where dD_s / D_s is obtained from Ito's formula. Similarly, the modified durations of the junior bond and equity are

$$\mathrm{Dur}(D_j) = -\frac{\partial D_j}{\partial V}\frac{V}{D_j}\frac{\rho\sigma_V}{v} - \frac{\partial D_j}{\partial r}\frac{1}{D_j}$$

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

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).[27] 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 III.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 $f(K_S + K_J) > K_S$, 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[28]

[27] 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.

[28] 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 $y^{\theta-\eta}$.

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

$$y = \frac{f(K_S + K_J)e^{-rt}}{V}$$

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

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

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

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

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

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

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

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

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

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

where $P(.)$ 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

The sample includes firms with asset return data available for the period from 1980 to 2012, excluding financial firms. Panel A provides the fraction of book debt (long-term debt plus debt in current liabilities) that is covered by bonds and loans found in the FISD and Dealscan databases. Panel B reports the fraction of bonds out of total assets across priority groups. We categorize each firm-month observation into one of four priority groups based on the number of different bond priority levels within the capital structure of the firm. For each priority group, we report average time-to-maturity and the fraction of high and low priority bonds out of total assets, separately for fixed and floating rate bonds. For firms with an odd numbers 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 even numbers or 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 C, 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 Coverage

Equally Weighted		Value Weighted	
Bonds	Bonds+Loans	Bonds	Bonds+Loans
65.2%	96.2%	59.8%	89.6%

Panel B: Debt Priority Distribution

		# of Priority	1	2	3	4 or more	Total
		# of Obs.	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 C: Leverage Distribution

	Avg.	25th Pct.	50th Pct.	75th Pct.
MA	8267.0	754.9	2061.8	5998.5
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

This table reports the modified duration of different classes of securities for the period from 1980 to 2012. We estimate the duration, β , from the following pooled regression for firms in five different groups sorted on leverage:

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

where R_t^i is the return on junior or senior bond, equity, or assets and i_t is the five-year, constant maturity Treasury yield. The senior and junior bond returns are obtained by value-weighting high and low priority bonds for each firm, 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 the market assets to book debt ratio from the previous year. To be included in these four, leverage-sorted groups, firms are required to have both high and low priority bonds with time-to-maturity longer than three years and bond amounts greater than 10% of the issuing firms' total debt. The reported duration estimates are the OLS estimates from pooled regressions for each leverage group. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. Numbers in parentheses are White robust standard errors.

Leverage Quintile		Senior	Junior	Equity	Asset
Zero	Avg. Ret			0.46%	0.46%
	Std. Dev. Ret			16.02%	16.02%
	β			-1.74***	-1.74***
				(0.15)	(0.15)
	R^2			0.0%	0.0%
1	Avg. Ret	0.64%	0.59%	0.62%	0.57%
	Std. Dev. Ret	3.44%	5.24%	10.66%	9.39%
	β	2.90***	2.22***	-1.70***	-1.20***
		(0.12)	(0.19)	(0.39)	(0.35)
	R^2	7.8%	1.8%	0.0%	0.0%
2	Avg. Ret	0.72%	0.77%	1.02%	0.90%
	Std. Dev. Ret	3.14%	4.48%	10.12%	7.70%
	β	2.49***	2.13***	-0.91***	-0.33
		(0.10)	(0.14)	(0.33)	(0.25)
	R^2	8.8%	3.3%	0.0%	0.0%
3	Avg. Ret	0.67%	0.75%	1.10%	0.85%
	Std. Dev. Ret	3.32%	4.38%	11.26%	6.94%
	β	2.13***	1.48***	-1.63***	-0.48**
		(0.10)	(0.13)	(0.35)	(0.22)
	R^2	6.4%	3.0%	0.0%	0.1%
High	Avg. Ret	0.85%	0.95%	1.28%	0.89%
	Std. Dev. Ret	5.23%	7.34%	17.04%	7.08%
	β	0.84***	0.60**	-2.10***	-0.59**
		(0.17)	(0.24)	(0.55)	(0.23)
	R^2	0.2%	0.0%	0.1%	0.0%

Table 3. Duration of Bonds and Equity: Within-Firm Difference Analysis

For bond and equity returns (R^m), we run the following 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^n is a return on a bond issued by the same firm whose priority is higher than that of security m. $\tau^m - \tau^n$ is the difference in coupon-weighted time-to-maturity between the securities *m* and *n*. 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 rate). When security *m* is equity, we consider all fixed-rate bonds issued by the same firm for *n* and the difference in time-to-maturity is just $-\tau^n$. Estimation is based on a pooled regression for the sample period from 1980 to 2012. To be included in the sample, bonds are required to have more than $100MM outstanding and time-to-maturity longer than 3 years. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. Numbers in parentheses are two-way 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)
$-(\tau^m - \tau^n)\cdot\Delta i$		0.125***		0.129***		0.009
		(0.020)		(0.039)		(0.028)
Intercept	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	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 Fixed Effect	No	No	Yes	Yes	No	No

Table 4. Duration of Bonds, Equity and Assets: Firm-Level Analysis

This table reports the interest rate sensitivity of debt, equity, and assets for the period from 1980 to 2012. We estimate coefficients for bond returns using the following pooled regression model:

$$R_{it+1} = \alpha + \beta_{it}\tau_{it}(\Delta i_{t+1}) + \theta_{it}\, RA_{it+1} + FE_{i,t} + \epsilon_{it+1}$$
$$\beta_{it} = \beta_0 + \beta_1 L_{it} + \beta_2 P_{it} + \beta_3 L_{it} P_{it} + \beta_4 Z_{it} + FE_{i,t}$$
$$\theta_{it} = \theta_0 + \theta_1 L_{it} + \theta_2 P_{it}$$

where R_{it} is bond i's return; τ_{it} is the coupon-weighted time-to-maturity of bond i; L_{it} is log book debt divided by market assets of firm i ($L_{it} = \log(1 + \Sigma K_j / V_{it})$); P_t is priority of a bond defined as one minus the fraction of bonds in terms of face value that are senior to that bond; and Z_{it} is a set of dummy variables for callable, convertible, putable, floating rate and asset-backed bonds; RA_{it} is firm i's asset return; $FE_{i,t}$ are ratings-based fixed effects; and Δi_t is the change in the five-year, constant maturity Treasury yield. For equity returns, we drop time-to-maturity by setting it equal to one, the priority variable, and the dummy variables from the specification. For asset returns, we also drop the asset return term. We report pooled OLS estimation results with two-way clustered standard errors by firm and time (in parentheses). *, **, and *** denote statistical significance at the 10, 5, and 1% levels. To be included in the sample, bonds are required to have face value greater than $100MM and time-to-maturity longer than 3 years.

Panel A: Duration of Bonds

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\tau(-\Delta i)$	0.238***	0.210***	0.162***	0.197***	0.321***	0.027*	0.347***	0.024
	(0.015)	(0.025)	(0.019)	(0.039)	(0.017)	(0.016)	(0.016)	(0.016)
$L \cdot \tau(-\Delta i)$	-0.014***	-0.052**	-0.061***	0.002				
	(0.005)	(0.021)	(0.016)	(0.070)				
$P \cdot \tau(-\Delta i)$	0.079***	0.109***	0.098***	0.099***				
	(0.015)	(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)
$Intercept$	0.007***	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)	(0.000)
$Rating\ FE$	N	N	N	Y	Y	Y	Y	Y
$Rating\ FE \cdot \tau\Delta i$	N	N	N	Y	Y	N	Y	N
R^2	0.055	0.055	0.254	0.254	0.206	0.204	0.173	0.171
N	644329	644329	643765	643765	652549	652549	652611	652611

Panel B: Duration of Equity and Asset Returns

	Equity		Asset	
	(1)	(2)	(3)	(4)
$\tau(-\Delta i)$	0.151	-0.669***	0.397***	0.550***
	(0.258)	(0.143)	(0.093)	(0.149)
$L \cdot \tau(-\Delta i)$	-0.000	-0.200**		0.139
	(0.159)	(0.090)		(0.103)
RA		1.644***		
		(0.020)		
$L \cdot RA$		0.219***		
		(0.011)		
Intercept	0.010***	-0.001***	0.009***	0.009***
	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.000	0.805	0.000	0.000
N	184,637	183,951	183,951	183,951

Table 5. Duration Estimates of Bonds and Equities Across Asset Durations

This table reports the interest rate sensitivity of bond and equity returns from 1980 to 2012 for subsamples based on asset duration. For bonds we estimate the following model:

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

where R_t is the bond return; τ_t is the coupon-weighted time-to-maturity of the bond; L_t is log book debt divided by market assets ($L_t = \log(1 + \Sigma K_i / V_t)$; P_t is priority of a bond defined as one minus the fraction of bonds in terms of face value that are senior to that bond; and Z_t is a set of dummy variables for callable, convertible, putable, floating rate and asset-backed bonds. For equity, we drop the time-to-maturity by setting it equal to one, the priority variable, and the dummy variables from the specification. Firms are sorted into tercile asset duration buckets based on asset duration estimated using rolling-window regressions of past 36 months of asset return on the negative of five-year Treasury bond yield changes. We exclude financials. We report pooled OLS estimation results with two-way clustered standard errors by firm and time (in parentheses). *, **, and *** denote statistical significance at the 10, 5, and 1% levels. To be included in the sample, bonds are required to have face value greater than $100MM and time-to-maturity longer than 3 years.

	Bond			Equity		
	Asset Duration Tercile			Asset Duration Tercile		
	Low	Mid	High	Low	Mid	High
$\tau(-\Delta i)$	-0.182***	0.133**	0.252***	-8.308***	-0.861	6.372***
	(0.068)	(0.052)	(0.035)	(0.633)	(0.537)	(0.621)
$L \cdot \tau(-\Delta i)$	-0.327***	-0.099**	0.061**	-2.467***	-0.587*	1.029***
	(0.047)	(0.041)	(0.026)	(0.392)	(0.355)	(0.396)
$P \cdot \tau(-\Delta i)$	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)			
Intercept	0.007***	0.007***	0.007***	0.013***	0.012***	0.012***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
R^2	0.022	0.056	0.071	0.012	0.000	0.014
N	163,976	175,578	178,344	41,605	31,877	33,846

Table 6. Regression of Correlations between Equity Returns and Treasury Returns

The dependent variables are the correlation between equity and 5-year Treasury bond returns (Columns 1 through 4) and the correlation between asset-neutral equity and 5-year Treasury bond returns (Columns 5 through 8), estimated from a 36-month rolling window of monthly returns. The equity return is the value-weighted average of stock returns on non-financial firms available 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 $R^e_{p,t+1} \equiv \Sigma_i w_{i,t}(R_{i,t+1} - \theta_{i,t} RA_{i,t+1})$ based on the regressions in Table 4. *BDMA* is book debt over the market value of asset of the firms in our sample. *Asset volatility controls* include the ratio of aggregate asset volatility of our sample firms to the volatility of changes in 5-year constant maturity Treasury yields, estimated using 36-month rolling windows. *Liquidity controls* include VIX; *ILLIQ(S)*, which is the capitalization-based proportion of zero daily returns across all firms, aggregated over the month; *ILLIQ(B)*, a monthly average of quoted bid-ask spreads of off-the-run bonds across all maturities; and the interaction between *ILLIQ(S)* and *ILLIQ(B)*. *Macro controls* include *DY*, the dividend yield based on Fama and French (1988); *DS,* the yield spread between BBB and AAA corporate bonds; *TS,* the term spread between 10-year and one-year constant maturity Treasury rates; and *TB,* the 3-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 rolling correlations on these regressors in a setting where the true R^2 is zero. All explanatory variables including interaction terms are standardized using the sample mean and standard deviations. The sample period is from 1986 to 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)
Constant	-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	0.339	0.525	0.867	0.890	0.453	0.453	0.756	0.814
R^2 (adj.)	0.271	0.395	0.547	0.520	0.385	0.323	0.436	0.444
N	317	317	317	317	317	317	317	317

Table 7. Regression of Correlations between Treasury Bond Returns and Corporate Bond Returns

The dependent variables are the correlation between bond portfolio and 5-year Treasury bond returns (Columns 1 through 4) and the correlation between asset-neutral bond portfolio and 5-year Treasury bond returns (Columns 5 through 8), estimated from a 36-month rolling window of monthly returns. We form equal-weighted high (*Senior)* and low (*Junior*) bond portfolios returns according to bond priority within a common set of firms. The asset-neutral corporate bond returns are estimated based on the regressions in Table 4. *BDMA* is book debt over the market value of asset of the firms in the sample. *Asset volatility controls* include the ratio of aggregate asset volatility of our sample firms to the volatility of changes in 5-year constant maturity Treasury yields, estimated using 36-month rolling windows. *Liquidity controls* include VIX; *ILLIQ(S)*, which is the capitalization-based proportion of zero daily returns across all firms, aggregated over the month; *ILLIQ(B)*, a monthly average of quoted bid-ask spreads of off-the-run bonds across all maturities; and the interaction between *ILLIQ(S)* and *ILLIQ(B)*. *Macro controls* include *DY*, the dividend yield based on Fama and French (1988); *DS,* the yield spread between BBB and AAA corporate bonds; *TS,* the term spread between 10-year and one-year constant maturity Treasury rates; and *TB,* the 3-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 rolling correlations on these regressors in a setting where the true R^2 is zero. All explanatory variables including interaction terms are standardized using the sample mean and standard deviations. The sample period is from 1992 to 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)
Constant	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	0.439	0.633	0.726	0.857	0.330	0.532	0.580	0.764
R^2 (adj.)	0.371	0.503	0.406	0.487	0.262	0.402	0.260	0.394
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	0.530	0.627	0.912	0.942	0.395	0.532	0.790	0.844
R^2 (adj.)	0.462	0.497	0.592	0.572	0.327	0.402	0.470	0.474
N	317	317	317	317	317	317	317	317

Table 8. Regression of Correlations between Equity Returns and Corporate Bond Returns

The dependent variables are the correlation between equity and bond portfolio returns (Columns 1 through 4) and the correlation between asset-neutral equity and asset-neutral bond portfolio returns (Columns 5 through 8), estimated from a 36-month rolling window of monthly returns. We form equal-weighted high (*Senior)* and low (*Junior*) bond portfolios returns according to bond priority within a common set of firms and also form corresponding equity return portfolios using the same set of firms. The asset-neutral corporate bond returns are estimated based on the regressions in Table 4. *BDMA* is book debt over the market value of asset of the firms in the sample. *Asset volatility controls* include the ratio of aggregate asset volatility of our sample firms to the volatility of changes in 5-year constant maturity Treasury yields, estimated using 36-month rolling windows. *Liquidity controls* include VIX; *ILLIQ(S)*, which is the capitalization-based proportion of zero daily returns across all firms, aggregated over the month; *ILLIQ(B)*, a monthly average of quoted bid-ask spreads of off-the-run bonds across all maturities; and the interaction between *ILLIQ(S)* and *ILLIQ(B). Macro controls* include *DY*, the dividend yield based on Fama and French (1988); *DS,* the yield spread between BBB and AAA corporate bonds; *TS,* the term spread between 10-year and one-year constant maturity Treasury rates; and *TB,* the 3-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 rolling correlations on these regressors in a setting where the true R^2 is zero. All explanatory variables including interaction terms are standardized using the sample mean and standard deviations. The sample period is from 1992 to 2012. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. The numbers in parentheses are Newey-West standard errors.

	Senior Bond and Equity				Asset-Neutral Senior Bond and Equity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.333***	0.333***	0.333***	0.333***	-0.809***	-0.809***	-0.809***	-0.809***
	(0.054)	(0.053)	(0.032)	(0.027)	(0.046)	(0.028)	(0.026)	(0.018)
BDMA	-0.016	-0.017	0.044	0.010	-0.014	-0.009	0.007	0.076*
	(0.042)	(0.042)	(0.040)	(0.034)	(0.030)	(0.027)	(0.029)	(0.041)
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	0.006	0.024	0.454	0.538	0.007	0.460	0.517	0.661
R^2 (adj.)	-0.062	-0.106	0.134	0.168	-0.061	0.330	0.197	0.291
N	317	317	317	317	317	317	317	317

	Junior Bond and Equity				Asset-Neutral Junior Bond and Equity			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.460***	0.460***	0.460***	0.460***	-0.702***	-0.702***	-0.702***	-0.702***
	(0.032)	(0.032)	(0.025)	(0.023)	(0.055)	(0.033)	(0.026)	(0.016)
BDMA	0.077***	0.077***	0.108***	0.109***	0.026	0.032	0.014	0.073***
	(0.026)	(0.025)	(0.026)	(0.031)	(0.041)	(0.025)	(0.029)	(0.023)
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	0.236	0.249	0.395	0.465	0.018	0.518	0.617	0.758
R^2 (adj.)	0.168	0.119	0.075	0.095	-0.050	0.388	0.297	0.388
N	317	317	317	317	317	317	317	317

Table 9: Estimation of Bond Factor Loadings

This table provides results from regressions of equity and bond returns on stock and bond market factors for six issuer-level credit rating portfolios. The equity and bond rating portfolios are value-weighted using the market values of equity and bonds, respectively. The stock market factors are the returns on the market portfolio, the small-minus-big factor, and high-minus-low factor from Ken French's website. We use two sets of bond market factors: (*Term, Def1*) in Panel A and (*Term, Def2*) in Panel B. *Term* is the return on long-term government bonds (the average of 10-, 20-, and 30-year T-bond returns) minus the 1-year T-bond return. *Def1* is the return on aggregate corporate bonds (the value-weighted average of investment and high-yield index returns from Citi's Yieldbook) minus the return on long-term government bonds used in Term. *Def2* is the return on aggregate corporate bonds minus 5-year T-bond returns. Panel C provides the differences in coefficients on *Term* and *Def* between Panel A and Panel B from GMM estimation with an identity weighting matrix with a Bartlett kernel of 4 lags. 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. The numbers in parentheses in Panels A and B are White robust standard errors and those in Panel C are from the GMM estimation. The sample period is from 1990 to 2012.

Panel A: DEF1 = Corporate Bond Index – Long-Term Treasury

	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)
Mkt	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	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 = Corporate Bond Index – Five-Year Treasury

	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)
Mkt	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	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 Difference

	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: Beta of Corporate Bonds

This table reports estimation results for the following regressions:

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

$$R_{t+1}^{B_i} - R_t^F = \alpha + \beta_1\left(R_{t+1}^{V_M} - R_t^F\right) + \beta_2\left(R_{t+1}^{M} - R_{t+1}^{V_M}\right) + \varepsilon_{t+1}$$

$$R_{t+1}^{B_i} - R_t^F = \alpha + \beta_1\left(R_{t+1}^{V_M} - R_t^F\right) + \varepsilon_{t+1}$$

where $R_{t+1}^{B_i}$ is bond portfolios returns, R_t^F is the one-month T-Bill rate, R_{t+1}^{M} and $R_{t+1}^{V_m}$ are aggregate equity and asset returns constructed using firms with asset return data available. We form 4-by-2-by-2 (time-to-maturity by credit ratings by priority) bond portfolios. The bond sample consists of nonfinancial firms with bond data available in the Lehman Brothers and EJV databases and also the CRSP and Compustat data available for the period from 1980 to 2012. The reported numbers are coefficient estimates, R^2, and the average numbers of securities in each portfolio. The column H_0 reports the difference in coefficients on R_{t+1}^{M} in the first regression and $R_{t+1}^{V_m}$ in the third regression. The differences are estimated using GMM with an identity weighting matrix. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. The numbers in parentheses are heteroskedasticity robust standard errors. The sample period is from 1980 to 2012.

		Investment Grade						High Yield					
TTM	Priority	R^M	R^V	R^M-R^V	R^2	N	H_0	R^M	R^V	R^M-R^V	R^2	N	H_0
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)			
			0.011^{***}		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 11: Time-Variation in Expected Returns

This table provides results from the predictive regressions of equity, bond, and asset excess returns on the dividend yield, term spread, and yield spread between high-yield corporate bonds and short-term government bonds. The equity, bond, and asset returns are value-weighted aggregate returns based on all firms in the sample with an available issuer-level credit rating, as reported in Table 6. The dividend yield, *dp*, is estimated following Fama and French (1988). The term-spread, *ys*, is 10-year, constant maturity Treasury yield minus the 3-month T-bill yield. The yield spread between high-yield corporate bonds and short-term government bonds is the yield on the high-yield market index from Citi's Yieldbook minus the 3-month T-bill rate. The column *Equity-Asset* reports the difference in coefficients between the equity and asset predictive regressions, estimated from the GMM with an identity weighting matrix. *, **, and *** denote statistical significance at the 10, 5, and 1% levels. The numbers in parentheses are the Newey-West standard errors with 4 lags, and the sample period is from 1991 to 2012.

	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	-0.20	0.09**	-0.12	-0.08*
	(0.13)	(0.05)	(0.10)	(0.04)
N	256	256	256	
R^2	1.86%	5.95%	1.77%	

Table 12: Understanding Default and Term Spreads

This table provides results from predictive regressions of equity excess returns on the dividend yield, term spread, and two different measures of the default spread. The dividend yield, *dp*, is estimated following Fama and French (1988). The term-spread, *ys*, is the 10-year, constant maturity Treasury yield minus the 3-month T-bill yield. 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 minus the 3-month T-bill rate. The second measure, *def(FF),* based on Fama and French (1986), 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 coefficients between the regressions based on the Keim and Stambaugh and Fama and French measures, estimated using 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. The numbers in parentheses are Newey-West standard errors, and the sample period is from 1991 to 2012.

	KS	FF		KS - FF
const	-0.01	-0.01	*dp(KS) - dp (FF)*	-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(KS)-ys(FF)*	0.22
	(0.30)	(0.24)		(0.19)
def(KS)	-0.20		*p-value*	0.14
	(0.13)			
def(FF)		-0.27*	*def(KS)-def(FF)*	0.07**
		(0.16)		(0.04)
N	256	256	*p-value*	0.04
R^2	1.86%	2.05%		

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

This figure plots the modified durations of senior debt, junior debt, and equity for the model given in equations (1) and (2). The parameter values are $r = 5\%$, $\sigma_v = 20\%$, $\tau = 5$, $K_s = 25$, $K_j = 25$, $q = 0.20$, $v = 2\%$, and $m = 7\%$

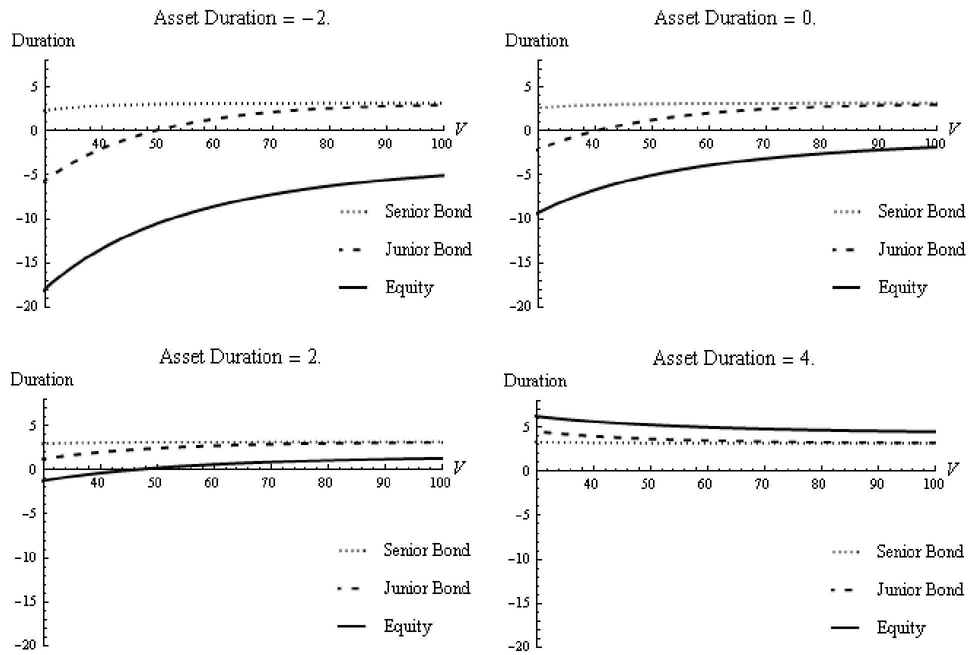


Figure 2. Correlation between Equity Returns and Treasury Returns

The figure documents the correlation estimated from a 36-month rolling window of monthly aggregate equity returns and government bond returns, along with a measure of the aggregate market leverage (market value of the assets over book value of debt). The solid line plots the correlations based on raw equity returns, while the long-dashed line adjusts the equity returns for their estimated asset duration. The period covers 1985 to 2012.

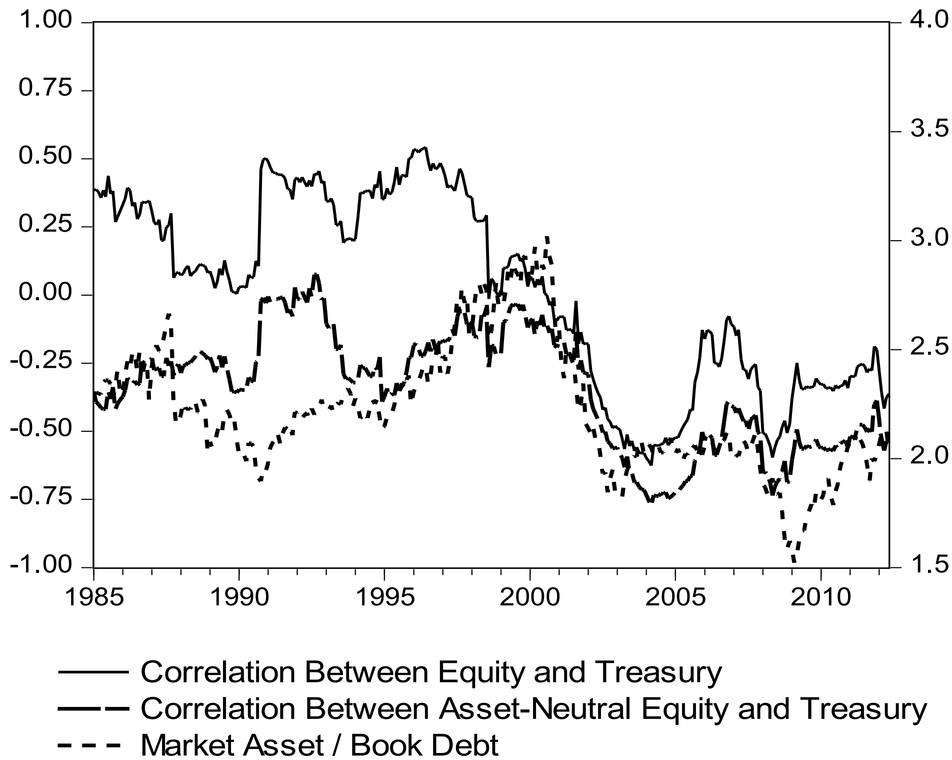


Figure 3. Time-Series of Time-Fixed Effects for Correlation Between Equity and Treasury Returns

This figure plots time-fixed effects from panel regressions of equity-Treasury correlations. The black line plots the time fixed effects from regressions without any control variables. The gray line plots time-fixed effects estimated after both leverage and asset durations are controlled for. We also plot 95% level confidence intervals.

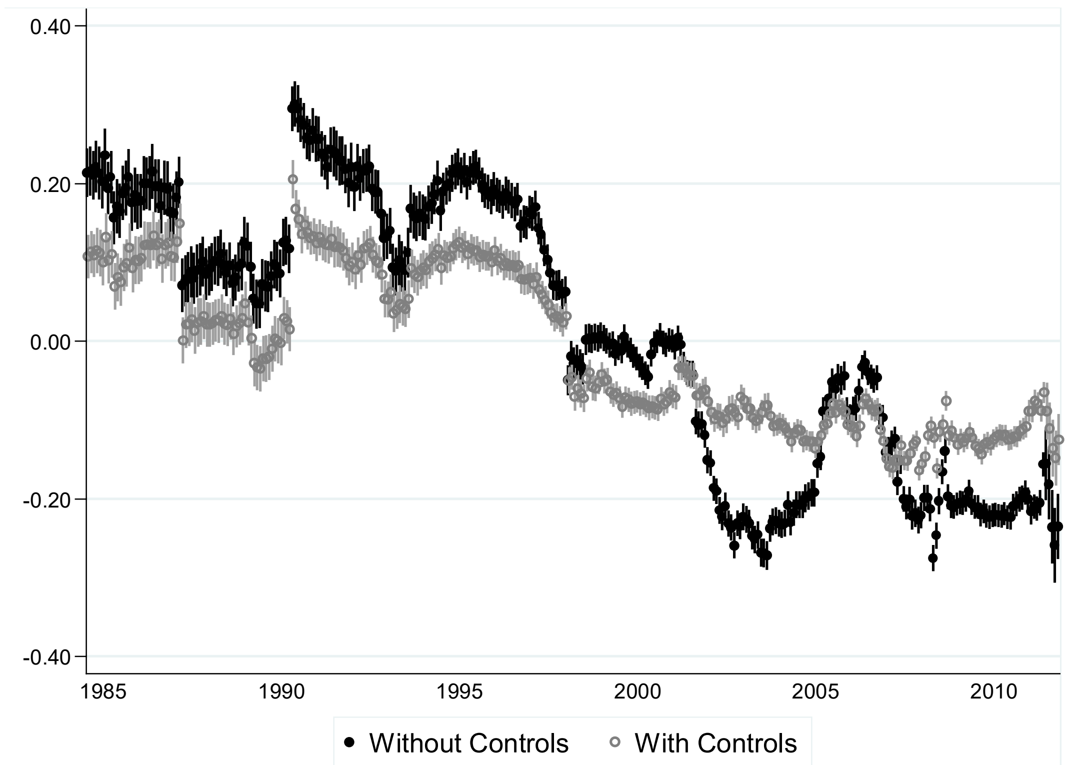
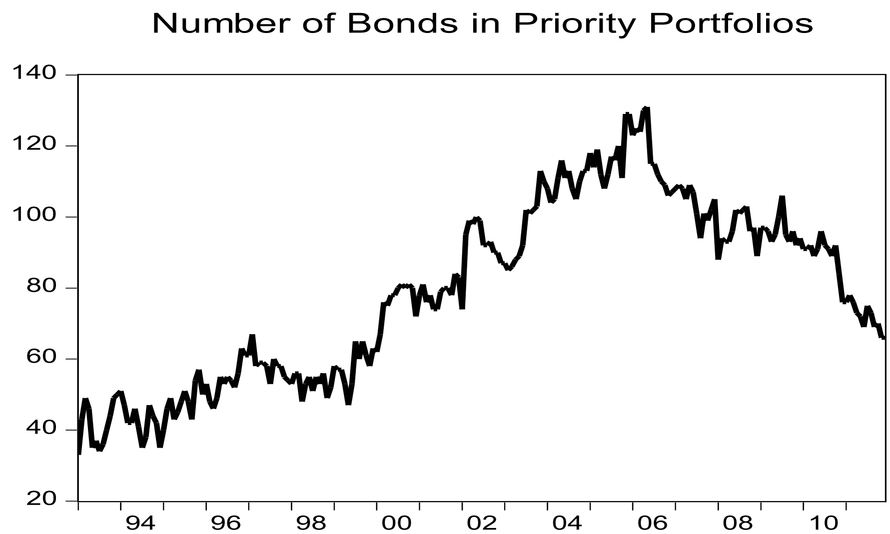


Figure 4. Characteristics of Corporate Bond Portfolios, Based on Priority

The figure documents the number of bonds and their average ratings through time for portfolios of corporate bond formed according to their priority within a common set of firms. The portfolios are broken into an equal-weight of high and low priority bonds. The period goes from 1992 onwards to make sure the portfolios contain at least 30 bonds. By construction, each of the two portfolios have the exact same number of bonds.



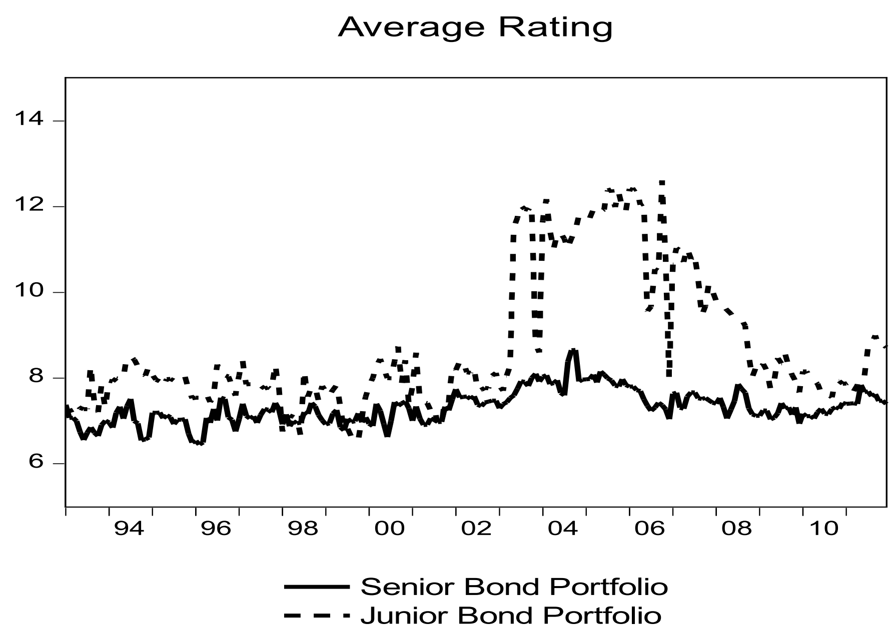
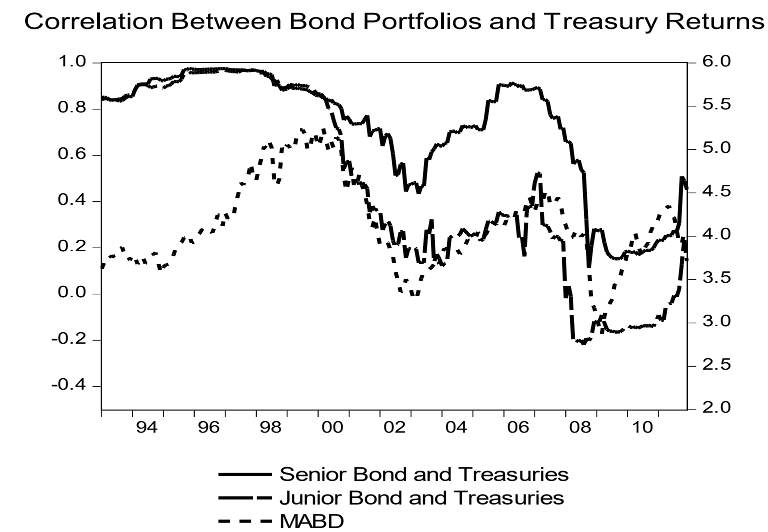


Figure 5. Correlation between Corporate Bond Returns and Treasury Bond Returns

The figure documents the correlation estimated from a 36-month rolling window of monthly aggregate bond returns and Treasury bond returns, along with a measure of the aggregate market leverage (market value of the assets over book value of debt). The first figure graphs the raw bond returns, while the second figure adjusts the bond returns for their estimated asset duration. Note that the two portfolios of corporate bonds have been formed according to their priority structure within a common set of firms. The portfolios are broken into an equal-weight of high and low priority bonds. The period goes from 1992 onwards to make sure the portfolios contain at least 30 bonds. By construction, each of the two portfolios have the exact same number of bonds.



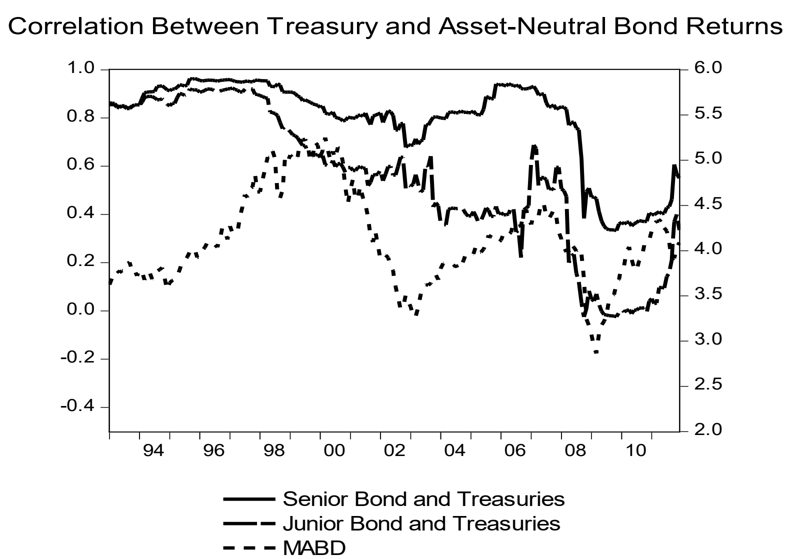


Figure 6. Correlation between Corporate Bond Returns and Equity Returns

The figure documents the correlation estimated from a 36-month rolling window of monthly aggregate bond returns and equity index returns, along with a measure of the aggregate market leverage (market value of the assets over book value of debt). The first figure graphs the raw bond and equity returns, while the second figure adjusts the bond and equity returns for their estimated asset duration. Note that the two portfolios of corporate bonds have been formed according to their priority structure within a common set of firms. The portfolios are broken into an equal-weight of high and low priority bonds. The period goes from 1992 onwards to make sure the portfolios contain at least 30 bonds. By construction, each of the two portfolios have the exact same number of bonds.