Systematic Risk and Debt Maturity

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Abstract

Aggregate debt maturity varies significantly over the business cycle. In the cross section, firms with higher systematic volatility choose longer debt maturity, while those with higher idiosyncratic volatility choose shorter maturity. Moreover, the maturity structure for a high beta firm is more stable over the business cycle than a low beta firm. We explain these empirical facts using a dynamic capital structure model with optimal maturity choice. short-term debt is less information-sensitive than long-term debt, but more prone to rollover risk and excessive liquidation. The risk premium embedded in the costs of liquidation causes firms with high systematic risk to favor long-term debt, as well as a more stable maturity structure over the business cycle. The endogenous maturity choice plays an important role in determining the term structure of credit spreads over the business cycle. In particular, it can reverse the prediction that firms with shorter maturity are more exposed to aggregate shocks.

1 Introduction

In aggregate data, corporate debt maturity has a clear cyclical pattern: average debt maturity is longer in economic expansions than in recessions (see Figure 1). We examine theoretically and empirically the link between debt maturity choice and firms' exposures to systematic risks, as well as the implications of endogenous maturity structure for the term structure of credit spreads.

Empirically, we provide several new facts about debt maturity and systematic risk. First, while firms with high idiosyncratic asset volatility have shorter debt maturity, those with high systematic volatility have longer maturity. Second, firms with higher asset beta choose longer maturity, especially after controlling for total asset volatility and leverage, and their maturity structure is relatively stable over the business cycle. In contrast, firms with low beta have significantly shorter debt maturity in a recession.

We explain these findings using a dynamic capital structure model with optimal maturity choice. The firm faces business cycle fluctuations in growth rates, uncertainty, and risk prices. It chooses how much debt to issue based on the trade-off between the tax benefits of debt and the costs of financial distress. For a given amount of debt, a longer maturity helps reduce the rollover risk, i.e., the risk of inefficient liquidation due to the firm's inability to refinance debt that is maturing. At the same time, long-term bonds are more information-sensitive than short-term bonds, and hence carry a premium, which is modeled in reduced form and depends on both the aggregate economic condition and firm-specific uncertainty. The firm balances between these tradeoffs when making its choice of debt maturity.

Systematic risk affects maturity choice in our model through two channels. First, since liquidation for firms with high systematic risk is more likely to occur in aggregate bad times, the embedded risk premium raises the expected liquidation costs due to rollover and causes these firms to favor long-term debt. Second, in recessions, higher uncertainty makes the problem of information asymmetry more severe, which raises the costs of issuing long-term debt. Firms with low systematic risk respond by reducing their debt maturity. However, high

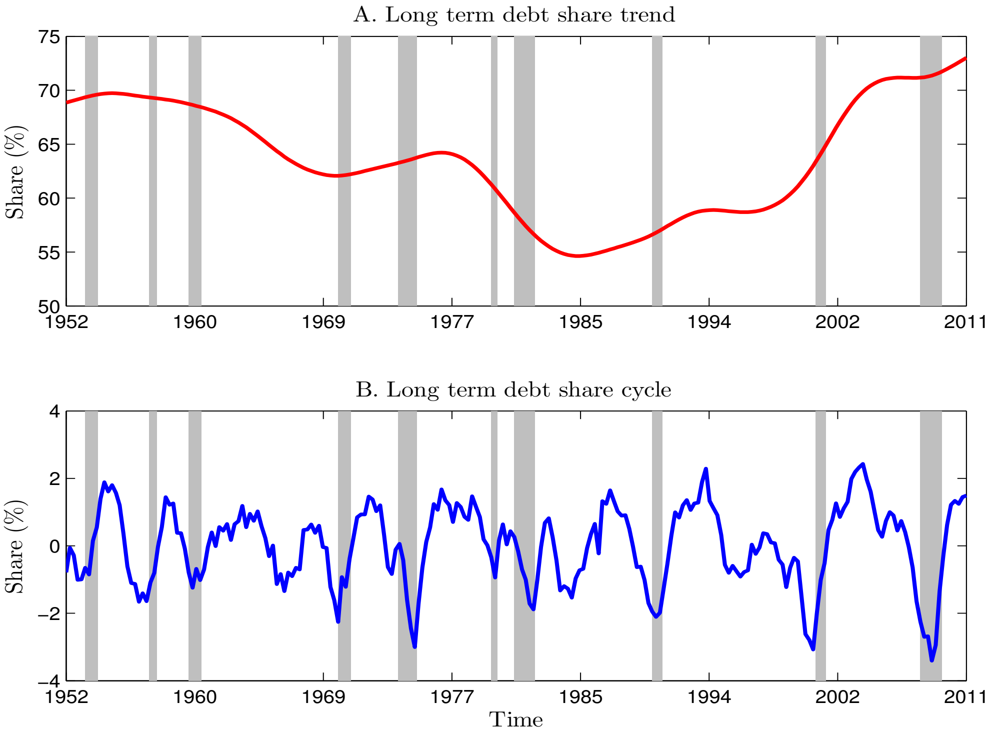

Figure 1: **Long-term debt share for nonfinancial corporate business.** The top panel plots the trend component of aggregate long-term debt share. The bottom panel plots the cyclical component. Source: Flow of Funds (Table L.102).

systematic risk firms become even more concerned with rollover risk in bad times, which offsets the higher information costs of long-term debt. As a result, the debt maturity for high beta firms is relatively stable over the business cycle.

The endogenous responses of firms' financing decisions to systematic risk play an important role in determining the term structure of credit spreads. Holding leverage and debt maturity fixed, higher systematic risk implies bigger swings in credit risk along with the market, especially for the short end of the credit curve. That suggests that the slope of the term structure will be more cyclical for high beta firms. Through lower leverage and longer debt maturity, firms with high systematic risk can effectively reduce the short-end fluctuations in credit risk, especially in bad times.

Our calibrated model matches the empirically measured effects of asset beta on debt maturity and generates reasonable predictions for leverage, default probabilities, and credit spreads. The model also quantifies the impact of maturity choice on the term structure of credit spreads. It generates slopes of the term structure of credit spreads that are pro-cyclical, and more so for firms with high volatility or high leverage. However, this effect is partially offset by the optimal maturity choice for firms with high systematic risk.

We use firm-level data from 1974 to 2010 to establish evidence on the link between systematic risk and debt maturity. We find that debt maturity is positively correlated with firms' exposure to systematic risk, especially after controlling for total asset volatility and leverage. A one-standard deviation increase in asset market beta lengthens firms long-term debt share, i.e. the percentage of total debt that matures in more than 3 years, by 6.3%. In addition, worsening macroeconomic conditions reduce firms' debt maturities, and its impact is larger for firms that are less exposed to systematic risk. For a firm with its asset market beta at the 10th percentile, its long-term debt share is 3.0% lower in recessions than that in expansions. For a firm with its asset market beta at the 90th percentile, its long-term debt share is almost unchanged from expansions to recessions. Finally, our findings are robust to different measures of systematic risk and different proxies for debt maturity.

We also test our model's implications on the term structure of credit spreads using firm-level Credit Default Swaps (CDS) data from 2002 to 2010. We find that the slope of a firm's credit spreads, measured by the spread difference between 10-year and 1-year CDS, is positively related to its systematic beta. A one standard deviation increase in asset market beta is associated with a 24 basis point increase in the spread between 10-year and 1-year CDS.

In an earlier empirical study of debt maturity, Barclay and Smith (1995) find that firms that have more growth options, are small, or have higher asset volatility choose shorter debt maturity. They do not separately examine the effects of systematic and idiosyncratic risks. Baker and Wurgler (2002) show that the fraction of long-term debt in net issuance predicts future excess bond returns negatively. They suggest that firms look at inflation, the real short-term rate, and the term spread to determine the maturity that minimizes the cost of capital. Several recent studies have documented that firms' financing behaviors change over the business cycle, e.g., Erel, Julio, Kim, and Weisbach (2011) and Mian and Santos (2011). Specifically on debt maturity, Erel, Julio, Kim, and Weisbach (2011) show that new debt issuances shift towards shorter maturity and more security during times of poor macroeconomic conditions. Mian and Santos (2011) show that the effective maturity of syndicated loans is procyclical. They also argue that firms actively manage their loan maturity through early refinancing of outstanding loans.

We find consistent evidence on the cyclicality of debt maturity using data from the Flow of Funds. Figure 1 shows the trend and cycle components (decomposed via the H-P filter) of the share of long-term debt for nonfinancial corporate business during the period of 1952-2010. The cycle component of the long-term debt share is strongly pro-cyclical, with an average drop in long-term debt share from peak to trough of 4%.[1] Our main contribution is to emphasize the role of systematic risk in firms' active maturity management and its implication for the cross section and time series of debt maturity choice as well as the term structure of credit spreads. It adds to the growing body of research on aggregate risk and financing decisions, which includes Almeida and Philippon (2007), Acharya, Almeida, and Campello (2010), Bhamra, Kuehn, and Strebulaev (2010), Chen (2010), and **?**, among others.

Our model builds on the dynamic capital structure models with maturity choice and endogenous default decisions. Without any additional costs for long-term debt, these models imply that the optimal debt maturity is infinity, because short-term debt rollover causes excessive liquidation. Possible costs for long-term debt include agency problems (**?**, Leland and Toft (1996)), information asymmetry (Flannery (1986), Diamond (1991)), or bond liquidity (He and Xiong (2012), He and Milbradt (2012)). We capture the costs of long-term debt in reduced form via a non-default term spread which is increasing in debt maturity and the idiosyncratic volatility of cash flows. The latter feature is consistent with models of information asymmetry between managers and outside investors, since higher firm-specific

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[1] We do not study the long-term trend in debt maturity in this paper. Greenwood, Hanson, and Stein (2010) argue that this trend mirrors the share of short-term government debt, which is consistent with firms behaving as macro liquidity providers.

uncertainty makes it more difficult for outside investors to learn about firm qualities such as the growth rate.

Finally, many papers have studied the term structure of credit spreads using structural models. Examples include Leland (1994), Leland and Toft (1996), Zhou (2001), Duffie and Lando (2001), Collin-Dufresne and Goldstein (2001), among others. Our paper contributes to this literature by linking macroeconomic conditions and systematic risk to firms' endogenous debt maturity choice. These connections are crucial for our understanding of the term structure of credit risk for corporations because the temporal distribution of maturity directly affects the probability of default at different horizons. The model also allows us to examine the impact of suboptimal maturity choice on credit spreads and the effect of endogenous maturity choice on the empirical measurement of rollover risk.

2 Empirical Evidence

In this section, we present evidence on the link between systematic risk and debt maturity both in the cross section of firms and in the time series.

2.1 Data

Our dataset merges the data from COMPUSTAT annual industrial files and the Center for Research in Securities Prices (CRSP) files for the period 1974 to 2010.[2] We exclude financial firms (SIC codes 6000-6999), utilities (SIC codes 4900-4999), and quasi-public firms (SIC codes greater than 8999), whose capital structure decisions can be subject to regulation. In addition, we require firms in our sample to have total debt that represents at least 5% of their assets.[3] All the variables are winsorized at the 1% and 99% level. Finally, we remove firm-year observations with extreme year-to-year changes in the capital structure (defined as having changes in book leverage or long-term debt share in the lowest or highest 1% of the

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[2] 1974 is the first year in which COMPUSTAT begins to report balance sheet information used to construct our proxies for debt maturity.

[3] Choosing a different threshold of 3% generates very similar results.

cross section of firms). These extreme changes likely correspond to major corporate events such as mergers, acquisitions, and spin-offs.

Following previous studies on the determinants of debt maturity (see Barclay and Smith (1995), Guedes and Opler (1996), and Stohs and Mauer (1996)), we construct our benchmark measure of debt maturity using the long-term debt share, which is the percentage of total debt obligations that are due in more than 3 years ($ldebt3y$). For robustness, we also measure long-term debt share using the percentage of total debt due in more than n years ($ldebtny$), with $n = 1, 2, 4, 5$. For each firm, COMPUSTAT provides information on the amount of debt in 6 maturity categories: debt due in less than 1 year (dlc), debt due in years two to five ($dd2$, $dd3$, $dd4$, and $dd5$), and debt due in more than 5 years. These information allow us to construct the above measures of debt maturity. In addition to the long-term debt share, we also construct a book-value weighted numerical estimate of debt maturity ($debtmat$) by assuming that the average maturity of the 6 COMPUSTAT maturity categories is 0.5 year, 1.5 years, 2.5 years, 3.5 years, 4.5 years, and 10 years, respectively.

Our primary measure of firms' exposure to systematic risk is the asset market beta. Since firm asset value is not directly observable, we follow Bharath and Shumway (2008) and back out asset betas from equity betas based on the Merton (1974) model (details of the procedure are in Appendix C). Equity betas are computed using past 36 months of equity returns and value-weighted market returns. In this process, we also obtain the Merton distance-to-default measure ($mertondd$), which is a proxy for firms' default probability, the firms' total asset volatility ($asset\ vol$), as well as the systematic and idiosyncratic asset volatilities ($sys\ asset\ vol$ and $id\ asset\ vol$). Moreover, following Acharya, Almeida, and Campello (2010), we also compute the "asset bank beta," which is based on the firm's exposure to a banking sector portfolio, and the "asset tail beta," which captures the firm's exposure to large negative shocks to the market portfolio. The details of these alternative beta measures are in Appendix C.

Previous empirical studies have found that debt maturity decisions are related to several firm characteristics, including firm size (log market assets, or $mkat$), abnormal earnings ($abnearn$), book leverage ($bklev$), market-to-book ratio ($mk2bk$), profit volatility ($profitvol$), asset maturity (*assetmat*), and default likelihood. We control for these firm characteristics in our main regressions.

Table 1 provides the summary statistics for variables used in our paper. The median firm has 85.1% of their debt due in more than 1 year, 55.9% of their debt due in more than 3 years, and 33.5% of their debt due in more than 5 years. There is also considerable cross sectional variation in all three measures. For example, the standard deviation of $ldebt3y$ (the percentage of debt due in more than 3 years) is 31.6%, and the interquartile rang of $ldebt3y$ is from 23.1% to 77.5%. Based on our numerical measure of debt maturity, the median debt maturity is 4.8 years, with a standard deviation of 2.6 years. The interquartile range of the debt maturity is from 2.9 years to 6.8 years. The median firm in our sample has book leverage of about 27.3%. The median asset market beta is 0.79, whereas the median equity beta is 1.07. The correlation among the different beta measures are in the Appendix. Finally, the median systematic asset volatility is 12.0%, while the idiosyncratic asset volatility is 29.9%.

2.2 Debt Maturity

We first examine the relation between debt maturity and firm risks using the Fama-MacBeth procedure. We regress long-term debt share on systematic and idiosyncratic asset volatility, which in turn are estimated using rolling 3-year regressions based on the CAPM model. Figure 2 plots the time series of the coefficients on the systematic and idiosyncratic volatilities and their 95% confidence intervals, which are computed using heteroscedasticity consistent standard errors.

The coefficient estimates for the systematic asset volatility is significantly positive for the majority of the sample years and is significantly positive for the overall sample. One exception is in the mid-2000s, when the coefficient becomes insignificant. These results indicate that, on average, firms with larger exposure to systematic risk have significantly more long-term debt. In contrast, the coefficient on the idiosyncratic asset volatility is significantly negative throughout the sample.

Barclay and Smith (1995) and Stohs and Mauer (1996)) have found a negative relation

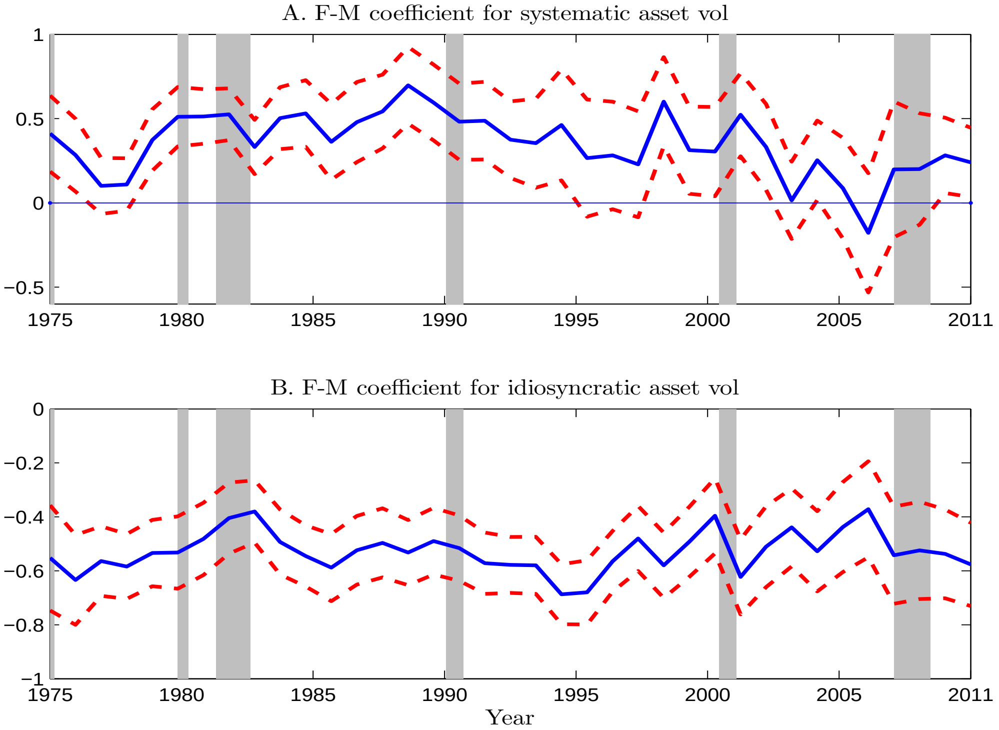

Figure 2: **Time series of Fama-MacBeth coefficients for systematic and idiosyncratic volatility.** This graph plots time series of coefficient estimates in a cross-sectional regression of long-term debt shares on systematic and idiosyncratic asset volatility. The confidence intervals are at 95% level.

between debt maturity and measures of firm volatility (the volatility of asset returns and changes in earnings). Our results suggest that this negative relation is driven by the negative relation between debt maturity and the idiosyncratic volatility. These results are consistent with the theory of debt maturity based on information asymmetries. As in models of informational frictions Flannery (1986) and Diamond (1991) that firms with larger potential information asymmetries issue more short-term debt. Intuitively, potential information asymmetry between managers and outside investors is likely more severe when firm-specific volatility is high, but should not be the case about the systematic volatility as managers do not necessarily know more about market-wide shocks than investors.

The average estimated coefficient of the systematic asset volatility is 0.31. To derive a better understanding of the economic significance of the result, we calculate the impact of moving from the tenth to the ninetieth percentile for the systematic asset volatility in our sample. The average estimated coefficient implies that this move increases the fraction of long-term debt by 7.1%.

In the following analysis, we investigate these patterns in more detail using multivariate regressions to tease out the impact of asset beta on debt maturity from other firm characteristics that have been found to affect a firm's debt maturity decision. We first run cross-sectional regressions using the Fama-MacBeth method (Fama and MacBeth (1973)), then run pooled regressions with industry-fixed effects and year-fixed effects following the empirical specification used in Barclay and Smith (1995), Guedes and Opler (1996), and Stohs and Mauer (1996). We expand their specifications by including our proxies for firms' exposure to risk:

$$ldebt3y_{i,t} = \alpha_i + \beta_1 risk_{i,t} + \beta_2 X_{i,t-1} + \beta_3 Year + \beta_4 Industry + \varepsilon_{i,t}, \tag{1}$$

where X includes the following firm-specific variables, $mkat$, $abnearn$, $bklev$, $mk2bk$, $assetmat$, $profitvol$, and $mertondd$. We also include year dummies to absorb time-specific effects, and industry dummies (3-digit SIC code) to control for industry fixed-effects. More over, we run regressions replacing $risk$ with other proxies for systematic and idiosyncratic risk. In the Fama-MacBeth regression, we compute robust t-statistics using Newey and West (1987) standard errors with 2 lags. In the pooled regression with industry-fixed effects, we adjust our standard errors by clustering the observations at the industry level. [4]

The regression results using $ldebt3y$ as a proxy of debt maturity are presented in Table 2. The first five columns report the results of the Fama-MacBeth regression, and the other columns report the results of pooled regressions with industry and year fixed effects. The coefficient estimate of the asset market beta in column (1) is positive with a magnitude of 0.011. It is not statistically significant probably due to the omitted variable bias. In fact, when we include both asset market beta and asset volatility in column (2), the coefficient

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[4] We obtain very similar results adjusting standard errors by clustering the observations in the same industry and in the same year.

estimate of asset market beta is statistically significant with a magnitude to 0.085, suggesting that a one-standard deviation increase in asset beta, keeping total asset volatility constant, is associated with a 5.3% increase in the fraction of long-term debt. The coefficient estimate of asset volatility is negative and statistically significant with a magnitude of -0.555, which implies that, keeping asset beta constant, a one-standard deviation increase in asset volatility is associated with a 10.6% reduction in firms' long-term debt share. Previous papers (see Barclay and Smith (1995), Guedes and Opler (1996), and Stohs and Mauer (1996)) have also found a negative relation between debt maturity and different measures of asset volatility, and interpreted their findings as supporting evidence of various theories in explaining a firm's debt maturity decisions. Our results indicate that there is a negative relation between debt maturity and idiosyncratic asset volatility since we keep asset beta constant in the regression. Hence the previous finding of a negative relation between debt maturity and a firm's total risk is mainly driven by its idiosyncratic component. In column (3), we include asset market beta, asset volatility and book leverage in the regression. The coefficient estimate of asset market beta further increases to 0.101, implying that a one-standard deviation increase in asset beta is associated with 6.3% increase in firms' long-term debt share. As high systematic firms choose lower leverage and longer debt maturity, controlling for leverage sharpens and further raises the effect of asset beta on debt maturity. Clear evidence of the opposite effects of systematic and idiosyncratic asset volatility on long-term debt share is presented in column (4) when we include only systematic and idiosyncratic asset volatility in the Fama-MacBeth regression. The coefficient estimate of the systematic asset volatility is positive, while the coefficient estimate of the idiosyncratic asset volatility is negative. They are both statistically significant. In column (5), we introduce other firm controls in the model. The coefficient estimate of the asset market beta is 0.045 with a t-statistic of 7.32. The estimated coefficient suggests that a one-standard deviation increase in the asset market beta lengthens firms' long-term debt share by 2.8%. The coefficient estimate of the asset market beta is more than doubled, compared with the estimate in the univariate regression, when other firm controls are introduced, due to the fact that firms' systematic and idiosyncratic asset volatility are positively correlated in our sample, and that firm controls, such as size, profit volatility and

Merton's distance-to-default, are highly correlated with firms' idiosyncratic asset volatility.

Column (6) - (8) reports quantitatively similar results when we run pooled regressions with industry-fixed effects and year-fixed effects. The coefficient estimate of asset market beta is statistically significant with a magnitude of 0.023 without firm controls in the regression (column (6)), and the estimated coefficient increases to 0.036 when we introduce firm controls in the regression (column (7)). When we include both systematic and idiosyncratic asset volatility (column (8)), in addition to firm controls, the coefficient estimate of the systematic asset volatility is positive and statistically significant with a magnitude of 0.279, and the coefficient estimate of the idiosyncratic asset volatility is negative and statistically significant with a magnitude of -0.051. The magnitude of the coefficient estimate of the idiosyncratic volatility is considerably smaller that the estimate when we do not include firm controls, due to the correlation between idiosyncratic asset volatility and other firm controls mentioned above.

Column (9)-(10) report regression results when we replace asset market betas with alternative beta measures. The results suggest that our finding of a significantly positive relation between debt maturity and a firm's exposure to systematic risk is robust to the method used to compute asset betas. In column (9), we show that a firm's exposure to banking sector risk affects its debt maturity in a way that is consistent with the theory. The coefficient estimate is also economically significant. Specifically, a one-standard deviation increase in a firm's asset bank beta lengthens its long-term debt shares by 1.6%. In column (10), we show that a firms' exposure to downside aggregate risk also affects its debt maturity. A one-standard deviation increase in a firm's asset tail beta lengthens its long-term debt shares by 1.9%[5].

The estimated coefficients of the control variables are in general consistent with previous findings. The results show that firms with large size, high abnormal earnings, high leverage, low market-to-book ratio, long asset maturity, high profit volatility and low default probability

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[5] When we use equity betas instead of asset betas in the regression, the coefficient estimate of equity betas is statistically significant with a magnitude of 0.14, implying that a one-standard deviation increase in a firm's equity beta lengthens its long-term debt share by 1.0%

are more likely to have longer debt maturity.

2.2.1 Impact of Business Cycles

In this section, we study the impact of business cycles on debt maturity. To measure macroeconomic conditions, we obtain recession/expansion dates from the National Bureau of Economic Research (NBER). Since fiscal year ends in December for a little more than half of firms in the sample, we construct a yearly recession dummy which equals to one if the fiscal year-end month for a firm is categorized as in recession according to NBER, and zero otherwise. We obtain very similar results if we categorize a fiscal year as in recession when at least one of the three months surrounding the fiscal year-end month is in recession.

To examine the impact of business cycles on debt maturity and whether the impact depends on firms' exposure to systematic risk, we modify the previous specification by adding a recession dummy variable and the interactions of the dummy variable with a firm's asset beta. We exclude year dummies from the specification so that time-specific effects are captured by the recession dummy. As shown in Figure 1, the aggregate debt maturity is U-shaped over the sample period. To make debt maturity comparable through business cycles, we include a quadratic deterministic time trend to control for the trend effect. We assume that debt maturity's loadings on the trend are the same for all firms. In the following robustness check, we allow the loadings to depend on firm characteristics. The regression results using different measures of firms' exposure to systematic risk are presented in Table 3. The results show that recessions shorten firms' long-term debt shares, and the reduction in debt maturity is larger for firms that have lower asset betas.

Column (1) includes only the recession dummy, asset market beta, and their interaction term in the regression. The coefficient estimate of the recession dummy is -0.034 with a t-statistic of -4.93, implying that the long-term debt share of an average firm drops by 3.4% from expansions to recessions, which is consistent with the plotted cyclical component of the aggregate long-term debt share in Figure 1. The coefficient of the interaction term between asset market beta and the recession dummy is 0.021 with a t-statistic of 2.65. The results show that for a firm with an asset market beta at the 10th percentile, its long-term debt share is 3.0% lower in from expansions to recessions, whereas the long-term debt share of a firm with asset market beta at the 90th percentile is unchanged from expansions to recessions. Including other firm controls (column (2)) generates very similar results.

Column (3) examines how the impact of business cycles on debt maturity depends on firms systematic and idiosyncratic asset volatility by including systematic and idiosyncratic asset volatility, and their interactions with the recession dummy in the regression. The coefficient estimate of the interaction term between the systematic asset volatility and the recession dummy is 0.100 with a t-statistic of 2.23, and the coefficient estimate of the interaction term between the idiosyncratic asset volatility and the recession dummy is 0.069 with a t-statistic of 2.48. Although systematic and idiosyncratic asset volatility have opposite cross-sectional effects on debt maturity, the impact of business cycles on debt maturity is larger for firms with either lower systematic volatility or lower idiosyncratic volatility. The results are very similar when we include other firm controls in the regression in column (4).

The regression results using asset bank betas and tail betas are reported in the column (5)-(8). The coefficient estimates of the interaction term between the asset bank beta and the recession dummy, and the interaction term between the asset tail beta and the recession dummy are all positive and statistically significant across different specifications. The economic significance of the coefficient estimates are comparable to those obtained using the asset market beta to measure firms' exposure to systematic risk.

2.2.2 Firm Characteristics and Business Cycles

In the analysis presented in the previous section, we allow the impact of business cycles on debt maturity to depend only on firms' exposure to systematic risk. However, changes in economic conditions could affect debt maturity through other firm characteristics. To examine this alternative hypothesis, we include the interaction terms between the recession dummy and all other firm controls in the regression. In addition, to study whether our results on the impact of business cycles on debt maturity depend on the deterministic quadratic time trend used in the previous analysis, we use the HP filter to extract a trend component from the aggregate long-term debt share, which is the value-weighted average of firms' fraction of total debt that matures in more than 3 years. We also run regressions using the aggregate trend to control for the trend effect. In Table 4, column (1) - (3) present the regression results using the quadratic time trend, and column (4) -(6) reports results using the aggregate trend. The results show that our findings that high systematic risk firms choose longer debt maturity and a more stable debt maturity over business cycles are robust to allowing business cycles to affect debt maturity through other firms characteristics. The coefficient estimates of the interaction term between the recession dummy and various measure of asset beta are all positive and statistically significant in five out of the six specifications. In the regression with the quadratic trend and asset market beta, the coefficient estimate of the interaction term between the recession dummy and asset market beta is 0.014 with a t-statistic of 2.07. The magnitude of the estimate is reduced by 0.06, compared with the coefficient estimate of the interaction term in Table 3 where we do not allow the impact of business cycles on long-term debt share to depend on other firm characteristics. The large reduction implies that the impact of business cycles on debt maturity also depends on other firm characteristics, which are possibly correlated with firms' exposure to the market risk. In contrast, the coefficient estimate of the interaction term between the recession dummy and the asset tail beta is hardly changes when we include the interactions between the recession dummy and other firm characteristics in the regression.

Studying the coefficient estimates of the interaction between the recession dummy and other firm controls, we find that, all else equal, firms with large size, high leverage, low market-to-book ratio, and low default probability reduce their debt maturity more from expansions to recessions. To gauge the economic significance of the estimates, we calculate the difference in the change of a firm's long-term debt share from expansions to recessions when the firm characteristic is increased from the 10th to the 90th percentile value. Based on the coefficient estimate of the interaction term in column (1), we find that the additional change in long-term debt share from expansions to recessions is -2.7%, -2.7%, 2.9%, -3.9%

respectively for the above-mentioned increase in firm size, abnormal earnings, book leverage, the market-to-book ratio, and Merton's distance-to-default.

In summary, our empirical analysis establishes a number of new facts on the relation between firm risk and debt maturity:

1. High systematic risk firms prefer longer debt maturity. A one-standard deviation increase in asset market beta is associated with a 6.3% increase in the long-term debt share, after controlling for total asset volatility and leverage.

2. High systematic risk firms prefer more stable debt maturity through the business cycle. For a firm with asset beta at the 90th percentile, its debt maturity hardly changes from expansions to recessions, whereas a firm with asset beta at the 10th percentile has its long-term debt share reduced by 3.0%.

3. The finding of a negative relation between firms' total volatility and debt maturity in previous papers is mainly driven by the negative relation between idiosyncratic volatility and debt maturity. A one-standard deviation increase in idiosyncratic asset volatility, keeping asset beta constant, reduces the long-term debt share by 10.6%.

3 Model

We now build a dynamic model of capital structure to capture the main empirical findings about debt maturity. A firm has cash flows that are exogenous. It chooses its capital structure in an optimal trade-off framework. Besides the standard trade-off between the tax benefits and bankruptcy costs of debt, the firm is also concerned with rollover risk, which affects its choice of debt maturity. Macroeconomic conditions affect the firm's cash flow dynamics and rollover risk, which in turn affect the firm's choice for leverage and maturity structure.

3.1 The economy and the firm

The state of the economy is described by a continuous time 2 state irreducible Markov chain, with the state denoted by $s_t \in \{G, B\}$, where we think of G as an expansion state and B as a recession state. The physical transition intensity between states i and j is given by $\pi_{ij}^{\mathbb{P}}$ so that between t and $t + dt$, the economy will switch from state i to j with probability $\pi_{ij}^{\mathbb{P}} dt$; the stationary probability of the economy being in state G is given by $\pi_{BG}^{\mathbb{P}} / (\pi_{BG}^{\mathbb{P}} + \pi_{GB}^{\mathbb{P}})$. We abstract from general equilibrium concerns by assuming an exogenous stochastic discount factor (SDF):[6]

$$\frac{dm_t}{m_t} = -r(s_t)dt - \eta(s_t)dZ_t^m + \sum_{s_t \neq s_{t-}} \left(e^{\kappa(s_{t-}, s_t)} - 1\right) dM_t^{(s_{t-}, s_t)} \tag{2}$$

where $r(\cdot)$ and $\eta(\cdot)$ are the state dependent risk free rate and market price of risk for Brownian shocks dZ_t^m, respectively. To capture variation in risk aversion across expansions and recessions, the risk free rate $r(\cdot)$ is set to be higher (lower) in state G (B) while the market price of risk is set to be higher (lower) in state B (G). $dM_t^{(j,k)} = dN_t^{(j,k)} - \pi_{jk}^{\mathbb{P}} dt$ is a compensated Poisson process capturing switches between states and $\kappa(i, j)$ embeds jump risk premia associated with regime switches so that the risk neutral jump intensity between states is given by $\pi_{ij} = e^{\kappa(i,j)} \pi_{ij}^{\mathbb{P}}$; risk aversion towards transitions to the recession state B is captured by setting $\kappa(G, B) > 0$ and $\kappa(B, G) < 0$ so that the SDF jumps upward going into recessions and downwards coming out of recessions.

We abstract from interactions between capital structure and investment by letting firm cash flows, y_t, to be exogenously given by the following process:

$$\frac{dy_t}{y_t} = \mu_{\mathbb{P}}(s_t)dt + \sigma_m(s_t)dZ_t^m + \sigma_f dZ_t^f \tag{3}$$

Cash flows are subject to both systematic and firm specific Brownian shocks as captured by dZ_t^m and dZ_t^f, respectively; $\mu_{\mathbb{P}}(\cdot)$ is the state dependent drift which is higher (lower) in the

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[6] See Chen (2010) for a general equilibrium setup that generates a similar SDF.

expansion (recession) state G (B); $\sigma_m(\cdot)$ captures systematic cash flow volatility, which is higher (lower) in the recession (expansion) state B (G), and σ_f captures idiosyncratic cash flow volatility which we assume to be fixed across states. Given the SDF m_t, risk neutral cash flow dynamics is then given by

$$\begin{aligned}\frac{dy_t}{y_t} &= \mu(s_t)dt + \sigma(s_t)dZ_t &(4)\\ dZ_t &= \rho(s_t)dZ_t^m + \sqrt{1-\rho(s_t)^2}dZ_t^f &(5)\end{aligned}$$

where the total cash flow shocks for the firm (dZ_t) contains both a systematic (dZ_t^m) and idiosyncratic (dZ_t^f) component; the risk neutral drift is given by $\mu(s_t) = \mu_{\mathbb{P}}(s_t) - \rho(s_t)\sigma(s_t)\eta(s_t)$, where $\sigma(s_t) = \sqrt{\sigma_m^2(s_t) + \sigma_f^2}$ is total volatility, of which the fraction $\rho_f(s_t) = \frac{\sigma_m(s_t)}{\sigma(s_t)}$ is attributable to systematic shocks.

The value of an unlevered firm not facing any taxes, $V(y, s)$, satisfies the following system of ODEs:

$$r(s)V(y,s) = y + \mu(s)yV_y(y,s) + \frac{1}{2}\sigma(s)^2y^2V_{yy}(y,s) + \sum_{s'\neq s}\pi_{ss'}\left[V(y,s') - V(y,s)\right] \quad (6)$$

The solution is given by $V(y, s) = v^*(s)y$ where we can solve for $\mathbf{v}^* := (v^*(G), v^*(B))'$ as

$$\mathbf{v}^* = \begin{pmatrix} r(G) + \pi_{GB} - \mu(G) & -\pi_{GB} \\ -\pi_{BG} & r(B) + \pi_{BG} - \mu(B) \end{pmatrix}^{-1} \begin{pmatrix} 1 \\ 1 \end{pmatrix} \quad (7)$$

This is a generalized Gordon growth formula taking into account both state dependent fundamentals as well as switches between states. For example, if there is no switching between states then equation (7) reduces to the usual Gordon growth formula $v^*(s) = (r(s) - \mu(s))^{-1}$.

3.2 Capital structure

To model the trade-off between the tax benefits and bankruptcy costs of debt, we assume the effective tax rate on corporate income is τ. Upon bankruptcy, debt-holders recover a fraction

$\alpha(s)$ of the firm's unlevered assets while equity-holders receive nothing.

The intuition for rollover risk and its impact on maturity choice is as follows: longer maturity debt bears a higher external financing premium, but is also less prone to rollover risk which we model following He and Xiong (2011). The higher external financing premium associated with long-term debt could be due to liquidity effects (e.g. Amihud and Mendelson (1986)) or adverse selection effects associated with long-term debt (e.g. Diamond (1991)); we do not take a stand on the friction driving the external financing premium, instead our model will capture these effects in a reduced form manner.

Firms arrive at an optimal choice of maturity by trading off financing costs against rollover risk. Note that this tradeoff is also influenced by the level of debt: firms with low leverage are less concerned about rollover risk and so gravitate towards shorter term debt, while highly levered firms have greater concern towards rollover risk and so issue longer maturity debt despite the higher external financing costs. These tradeoffs also vary over the business cycle; for example, rollover risk is more of a concern during recessions when external financing is more difficult to obtain and market are less liquid. We will model these business cycle effects using Markov-modulated dynamics.

The choice of capital structure is parameterized by the 4-tuple (P, λ, m_G, m_B). P is the face value of debt and λ is the coupon rate so that $C = \lambda P$ is the (instantaneous) coupon. In order to capture dynamic debt maturity, we allow debt maturities m_G and m_B to be state dependent. For tractability, we adopted the maturity structure of Leland (1998): at any instant in state $s \in \{G, B\}$, a constant fraction $1/m_s$ of outstanding debt gets retired at face value P so that the average debt maturity in state s is given by m_s.

The value of a unit of debt t years after issue (assuming that bankruptcy has not yet occurred) is given by

$$\begin{aligned} d(t, y_t, s_t) \;=\; \mathbb{E}_t \Bigg[& \int_t^{T_B} e^{-\int_t^u \left(r(s_v)+\ell_D(\sigma_f, m_{s_v}, s_v)\right) dv} e^{-\frac{1}{m_{s_u}} u} \left(C + \frac{1}{m_{s_u}} P \right) du \\ & + e^{-\int_t^{T_B} \left(r(s_u)+\ell_D(\sigma_f, m_{s_v}, s_v)\right) du} e^{-\int_t^{T_B} \frac{1}{m_{s_u}} du} \alpha(s_{T_B}) V_B(s_{T_B}) \Bigg] \end{aligned} \tag{8}$$

where T_B is the stopping time for bankruptcy; C and P/m_{s_t} are, respectively, the total coupon and redemption value paid out by the firm at each instant, the fraction of which accruing to $d(t, y, s)$ decays at state dependent rate $\frac{1}{m_s}$; $\alpha(s_{T_B})V_B(s_{T_B}) = \alpha(s_{T_B})v^*(s_{T_B})y_{T_B}$ is the state dependent recovery value upon bankruptcy for all debtholders, a fraction $e^{-\int_t^{T_B} \frac{1}{m_{s_u}} du}$ of which accrues to $d(t, y, s)$.

We capture external financing costs in a reduced form manner by positing a spread, $\ell_D(\sigma_f, m, s_t)$, at which debt gets priced. This spread is a function of three components: the macroeconomic condition s_t, firm specific idiosyncratic volatility σ_f and the choice of debt maturity m. External financing is more costly during recession so that $\ell_D(\cdot, \cdot, B) > \ell_D(\cdot, \cdot, G)$. To capture differences in liquidity costs and/or adverse selection associated with long-term debt, we specify $\ell_D(\cdot, m, \cdot)$ to be an increasing function of debt maturity m. Finally, we capture investors' risk aversion towards asymmetric information over firm specific risk by letting $\ell_D(\sigma, \cdot, \cdot)$ be an increasing function of firm specific volatility σ_f. We have in mind an economy where firms have superior information about it's own idiosyncratic risk relative to investors, and this form of asymmetric information leads to adverse selection in the credit markets and ultimately results in an increased external financing premium. We parameterize the external financing premium as

$$\ell_D(\sigma_f, m, s_t) \quad = \quad f(\sigma_f)h(m, s_t) \tag{9}$$

where $f(\sigma_f) = 1 + a_f\sigma_f^2$ and $h(m, s) = b_h(s)(\exp(c_h(s)m) - 1)$. We normalize $f(0) = 1$ so that $h(m, s)$ can be interpreted as the financing costs for a firm free from information asymmetry. This is a simple reduced form way of capturing external financing costs over the business cycle.

The Feynman-Kac equation for an individual bond t years after issue, $d(t, y_t, s_t)$, is given by

$$\begin{aligned}[r(s)+\ell_D(m,s)]\,d(t,y,s) &= e^{-\frac{1}{m_s}t}\left(C+\frac{1}{m_s}P\right)+\frac{\partial}{\partial t}d(t,y,s)+\mu(s)y\frac{\partial}{\partial y}d(t,y,s)\\ &\quad+\frac{1}{2}\sigma(s)^2y^2\frac{\partial^2}{\partial y^2}d(t,y,s)+\sum_{s'\neq s}\pi_{ss'}\left[d(t,y,s')-d(t,y,s)\right]\end{aligned} \tag{10}$$

with boundary condition at default:

$$d(t,y_B(s),s) = e^{-\frac{1}{m_s}t}\alpha(s)v^*(s)y_B(s) \tag{11}$$

As in Leland (1998), $d(t,y,s)=e^{-\frac{1}{m_s}t}\bar{d}(y,s)$ where $\bar{d}(y,s)$ is the value of newly issued debt, the characterization of which we leave for the appendix. To maintain a stationary structure for the total value of debt, we assume that the firm replaces expiring debt with new debt of identical terms. Similar to He and Xiong (2011), this forms the basis for rollover risk in our model: the net instantaneous cash flow due to debt rollover, $\frac{1}{m_s}\left(\bar{d}(y,s)-P\right)$, which depends on both firm and macroeconomic conditions, is born by equity holders prior to default. Depending on the prevailing macroeconomic conditions, debt rollover could be prohibitively costly for equity holders. Ex-ante, these concerns will be reflected in the firm's choice of capital structure (both in terms of the level of leverage and the maturity structure), as well as the pricing of the firm's equity and debt. All else equal, rollover risk is of greater concern for firms with higher systematic cash flow risk: these firms are more likely to encounter cash flow shortfalls precisely when external financing is most expensive; to circumvent this, these firms prefer longer debt maturities despite the higher liquidity premia.

Given the stationary debt structure, equity value satisfies the following Feynman-Kac equation

$$\begin{aligned}r(s)E(y,s) &= NC(y,s)+\mu(s)y\frac{\partial}{\partial y}E(y,s)+\frac{1}{2}\sigma(s)^2y^2\frac{\partial^2}{\partial y^2}E(y,s)\\ &\quad+\sum_{s'\neq s}\pi_{ss'}\left[E(y,s')-E(y,s)\right]\end{aligned} \tag{12}$$

Notice that the equity is discounted at $r(s)$, so that there is no liquidity adjustment for equity. While such liquidity effects do exist in equity markets (see for example, Pastor and Stambaugh (2003)), we focus on bond market illiquidity since bond markets are much more illiquid relative to equity markets. The instantaneous net cash flow accruing to equity holders of an ongoing firm is given by

$$NC(y,s) = (1 - \underbrace{\tau}_{\text{tax rate}})\Big(\underbrace{y_t}_{\text{EBIT}} - \underbrace{C}_{\text{Interest expense}}\Big) + \underbrace{\frac{1}{m_s}\left(\bar{d}(y,s) - P\right)}_{\text{Rollover gain}} \qquad (13)$$

Net cash flows depend on both firm specific conditions as well as macroeconomic conditions which influence both financing costs (in the form of rollover costs) and firm profitability: during expansions, higher cash flows and lower rollover costs combine to increase firm profitability, while the opposite holds during recessions.

The boundary conditions for equity at default are:

$$E(y_B(s);s) = 0 \qquad (14)$$

$$\frac{\partial}{\partial y}E(y_B(s);s) = 0 \qquad (15)$$

The first condition states that equity value is zero at default. The second is the smooth-pasting condition that ensures that the default boundary $y_B(s)$ is optimal. We obtain analytic expressions (up to roots of a system of non-linear equations) for equity value in the appendix.

Having discussed the value of debt and equity given the capital structure in place, we now state the firm's capital structure decision. The firm takes as given, prices as summarized by the pricing kernel m, the cash flow process y_t, tax rates τ, bankruptcy costs $\alpha(s)$, and bond liquidity spreads $\ell_D(\sigma_f, m, s)$, and chooses capital structure (P, λ, m_G, m_B) in order to maximize the initial value of the firm:

$$\max_{P,\lambda,m_G,m_B} E(y_0, s_0; P, \lambda, m_G, m_B) + \bar{d}(y_0, s_0; P, \lambda, m_G, m_B) \qquad (16)$$

In order to reduce the dimension of the problem, we will exogenously fix the coupon rate λ in the calibration exercises.

4 Quantitative Analysis

4.1 Calibration

The transition intensities are given by $\pi_G^{\mathbb{P}} = 0.1$ and $\pi_G^{\mathbb{B}} = 0.5$, which implies that the stationary probability of being in an expansion (recession) is 5/6 (1/6). We set the market price of jump risk $\kappa(G) = -\kappa(B) = \ln 3$, which implies that the risk-neutral transition probability from the good state to the bad state is three times that of the physical probability, while the risk-neutral transition probability out of the bad state is only a third of the physical probability. The market prices of risk for Brownian shocks in the two states are set to $\eta(G) = 17\%$ and $\eta(B) = 43\%$. The riskfree rate $r(s)$ is calibrated to match the first two moments of the riskfree rate in the data resulting in $r(G) = 4.3\%$ and $r(B) = 2.2\%$. Table 5 contains parameters for our baseline model.

For the cash flow process, we set $\mu_{\mathbb{P}}(G) = 4.3\%$ and $\mu_{\mathbb{P}}(B) = 2.2\%$, implying an unconditional average growth rate of 4%. The idiosyncratic cash flow volatility of the benchmark firm is $\sigma_f = 20\%$, while the systematic volatility of $\sigma_m(G)$ and $\sigma_m(B)$ are calibrated to generate an asset beta of 0.79, which is the median asset beta in our sample of public nonfinancial firms. Later on, we generate cross sectional variations in asset beta by changing firms' idiosyncratic volatility σ_f while adjusting the systematic volatility simultaneously so that the total volatility of cash flow remains the same as the benchmark firm. Other parameters include the bankruptcy recovery rate $\alpha = 0.65$, the effective tax rate $\tau = 20\%$, and the coupon rate $\lambda = 8\%$.[7]

The remaining specification for $\ell_D(\sigma_f, m, s)$ can be found in the table. The parameters were chosen to closely match our empirical findings: controlling for total volatility, we target

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[7] Alternatively, we could force coupons to adjust so that debt is issued at par.

(i) optimal maturities of 5.5 and 5 years in states G and B respectively for the unit beta firm, (ii) stable maturity of 6 years across states for the high beta firm, and (iii) maturities of 5 and 4 years in states G and B respectively for the low beta firm; further, controlling for systematic risk, we target (iv) optimal maturities of 5.5 and 6 years in states B and G respectively for a firm with low idiosyncratic risk and (v) optimal maturities of 5.5 and 4.5 years in states G and B respectively for a high idiosyncratic risk firm. Overall, our specification allows 5 parameters for external financing costs (i.e. $\alpha, b_h(G), b_h(B), c_h(G)$ and $c_h(B)$) to match a set of 10 moments for optimal maturities across states. Judging from Figure 3, our calibration is able to closely match 8 of the 10 targeted points.

For the purpose of calculating model implied betas, we exogenously specify a dividends process for the market. The drift of dividend growth under the physical measure is the same as the drift for cash flow growth for the baseline firm, and the volatilities are chosen to imply an annual market return of 8.1%. Details for calculating betas are given in the appendix.

The model implications for the benchmark firm are summarized in Table 6. The asset beta in the baseline calibration is 0.76 which is close to the median asset beta in our sample. The optimal capital structure choice involves an initial leverage of 35.6% and 39.4% across states, and an average maturity structure of 5.2 and 4.5 years in state G and B respectively.

4.2 Maturity choice

To illustrate how systematic risk affects firms' maturity structure, we compute the optimal debt maturity for firms with different asset beta. Since changes in total volatility will affect default risk and hence the choice of optimal maturity, we change asset beta by changing the composition of systematic vs. idiosyncratic volatility of cash flows while holding the total cash-flow volatility constant. This approach allows us to isolate the effect of systematic risk on debt maturity.

Panel A of Figure 3 shows the results. Controlling for total volatility, optimal debt maturity increases with asset beta in both the expansion and recession state. This is consistent with the intuition that firms with high systematic risk face higher rollover risk and will prefer

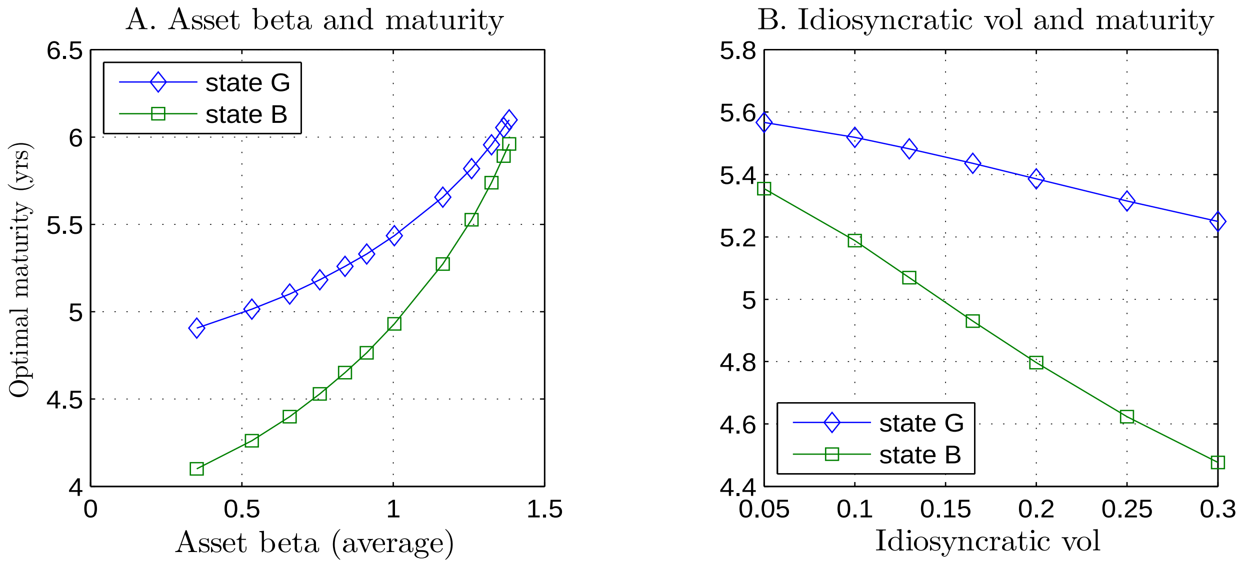

Figure 3: **Optimal debt maturity.** Panel A holds fixed the total amount of volatility while letting systematic volatility vary and then plots the resulting choices of optimal maturity across states. Panel B holds fixed the amount of systematic volatility whilst varying the amount of idiosyncratic volatility and plots the resulting choices of optimal maturity across states.

longer maturity despite the higher non-default spread associated with longer term debt. Moreover, the graph shows that the increase in debt maturity with asset beta is faster in a recession than in an expansion. These results are all consistent with our earlier empirical findings, which is as expected because the non-default term spreads are calibrated to match the effect of systematic risk on debt maturity we estimated from the data.

More on the intuition for maturity choice: the marginal benefit versus cost of long maturity — liquidity spread vs. default losses ...

Panel B of Figure 3 examines what happens when we increase idiosyncratic risk while holding fixed the amount of systematic risk of the firm. We see that this has a negative effect on optimal debt maturity, which again matches our empirical findings. The plot does suggest that the negative effect of idiosyncratic volatility on maturity become stronger in bad times, whereas in the data it appears to be the opposite case (although the difference is small).

To understand better why the maturity choice for firms with high systematic risk is more stable, we compare the credit spreads for different choices of maturity in state B against the non-default term spreads in **??**. As expected, longer maturity reduces the rollover risk and hence lowers the credit spread. This is especially true for firms with higher asset betas, as shown in Panel A. At the same time, the non-default term spread is increasing with maturity. When firms trade off between these two effects, those with higher betas put more weight on reducing rollover risk than those with lower betas, resulting in longer maturity choice (less reduction in maturity from state G) for them. In addition, our specification of the non-default term spread implies that it rises faster with maturity for firms with high idiosyncratic volatility. This feature further increases the difference in maturity choice in recession for high-beta and low-beta firms.

4.3 Implications for credit spreads

The interaction between rollover risk and debt maturity has interesting implications for credit spreads: on the one hand longer maturities decrease credit spreads by lowering default probabilities, while on the other hand longer maturities tends to increase credit spreads by increasing liquidity costs. This illustrates the difficulty in decomposing credit spreads into default and liquidity components: capital structure choices are made after considering both firm specific and macroeconomic conditions so that default boundaries depend both on firm fundamentals as well as market liquidity. Further, our model illustrates that such interactions between default risk and liquidity risk is nonlinear, thus highlighting the empirical difficulties in decomposing credit spreads into default and liquidity components. The top panels of **??** shows the impact of suboptimal maturity choice on the term structure of credit spreads for a firm with optimal leverage and a firm with high leverage. The bottom panels show that, with high leverage, high beta firms would respond more to a change in aggregate economic condition than low beta firms. However, the differences are significantly smaller when measured at optimal leverage.

Rollover risk: with exogenous maturity choice, shorter maturity leads to stronger reaction over the business cycle. The opposite can be true when maturity choice is endogenous. Firms

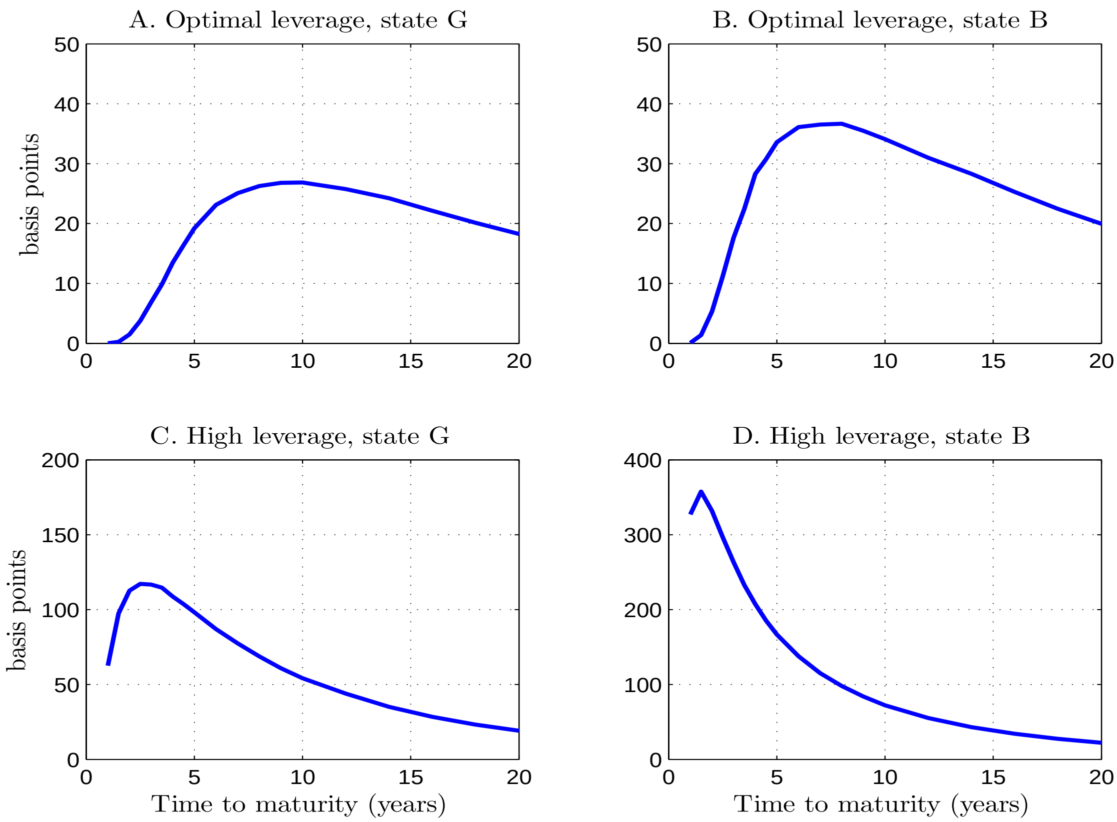

Figure 4: **Impact of maturity choice on the term structure of credit spreads.** This figure plots the increase in credit spreads when the benchmark firm's debt maturity in state B is reduced by half. In Panels A and B, the firm's leverage is at the optimal level, with interest coverage of 2.4. In Panels C and D, the firm's interest coverage is fixed at 1.2.

with longer maturity tend to have higher beta, especially in bad times. Figure 5 ...

5 Term Structure of Credit Spreads

We measure the slope of credit spreads as the spread difference between long-term and short-term credit default swaps (CDS). We obtain individual firm-level CDS spreads with maturity 1 year, 2 years, 3 years, 5 years, 7 years, 10 years, 20 years, and 30 years from Markit, and match firms with those from COMPUSTAT. We use the spread difference between 10-year and 1-year CDS as our benchmark proxy ($cdsslope1$) for the slope of credit spreads. We also use the spread difference between 5-year and 1-year CDS as an alternative measure

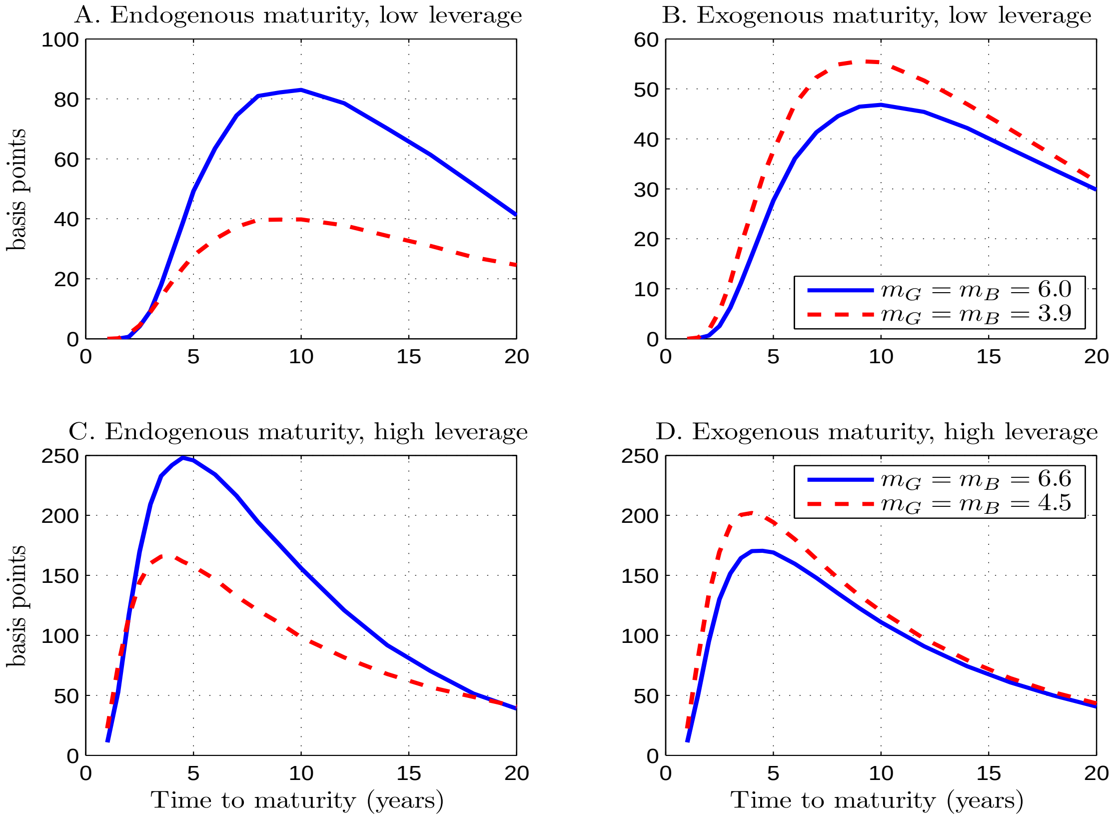

Figure 5: **Credit spread changes over the business cycle.** This figure illustrates the impact of the change in macroeconomic condition on credit spreads for firms with endogenous vs. exogenous maturity choice.

($cdsslope2$). The monthly and yearly CDS data is available from 2002 to 2010.

CDS data is available for 475 firms, a small sample comparing to firms available in the COMPUSTAT industrial file. The average CDS spread for these firms is 1.47% for 1 year, 1.76% for 3 years, 2.00% for 5 years, and 2.11% for 10 years. The average slope of CDS spreads is positive. The average spread difference between 10 years and 1 year CDS is 64 basis points, and the average spread difference between 5 years and 1 year is 53 basis points. The results indicate a sharp increase of average CDS spreads from 1 year to 5 years. The curve flattens out after 5 years. There is a large variation in CDS slopes. The standard deviation of $cdsslope1$ and $cdsslope2$ is 216 basis points and 168 basis points respectively. Comparing firm characteristics between those with CDS data and those without, we find that

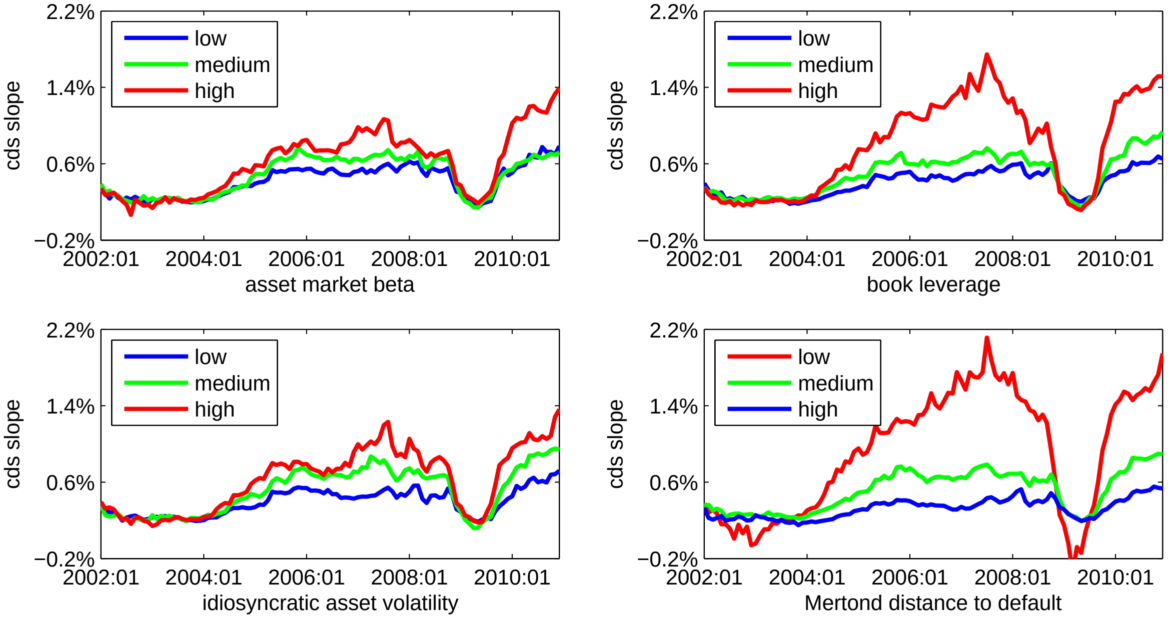

Figure 6: **CDS Slope Sorted by Firm Characteristics** This graph plots the monthly CDS slope (CDS10y - CDS1y) of portfolios sorted by asset market beta, book leverage, idiosyncratic asset volatility, and Merton's distance to default.

the average firm with CDS data available is larger, lower profit volatility, and less likely to default. It has comparable book leverage, slightly higher market-to-book ratio and longer asset maturity. It also has lower total asset variance entirely due to a smaller idiosyncratic component. Its various systematic betas are comparable to the entire sample.

In this section, we empirically test the model's predictions about the term structure of credit spreads.

We measure the slope of credit spreads using the spread difference between long-term and short-term CDS contracts written on available firms in our sample. Studying term structure of credit spreads at the firm level instead of at the portfolio level avoids the bias pointed out in Helwege and Turner (1999). We compute the slope of credit spreads using the spread difference between 10-year and 1-year CDS contracts. Before we run multivariate regressions to test our model's cross-sectional and time-series implications on the relation between asset beta and the slope of credit spreads, We first examine the univariate relation between the CDS slope and firm characteristics, and investigate how the relation changes through business cycles. Each year, we sort firms with CDS data into three groups according to the ranking of their firm characteristics, and compute the median CDS slope for each group. The time-series plots of the CDS slope for portfolios sorted by asset market beta, book leverage, idiosyncratic asset volatility, and Merton's distance-to-default measure are presented in Figure 6.

The plots show that there is a positive cross-sectional relation between the CDS slope and the asset market beta. The average CDS slope of firms in the lowest asset market beta group is 42 basis points, where the average CDS slope of firms in the highest asset market beta group is 61 basis points. In addition, there is a positive cross-sectional relation between the CDS slope and book leverage, and between the CDS slope and idiosyncratic asset volatility. There is a negative cross-sectional relation between the CDS slope and Merton's distance-to-default measure. On average, firms with low book leverage, idiosyncratic asset volatility, and default probability have low CDS slopes. Moreover, there is a large variation in the CDS slope through business cycles with the CDS slope declining significantly in recessions. It probably reflects that worsening macroeconomic conditions increase either firms' short-term default probability or default risk premium more than their long-term counterparts.

Furthermore, the variation in the CDS slope through business cycles is much larger for firms with high leverage and high default probability than that for firms with high asset market beta. It is consistent with the prediction of the model that high asset beta firms choose low leverage and long debt maturity. Their optimal capital structure choices dampen the impact of business cycles on the short-term default risk, resulting a more stable term structure of credit spreads over time.

5.1 Cross-Section

To separate the impact of other firm characteristics on the slope of CDS spreads, we run regressions of the slope of credit spreads on our measures of firms' exposure to risk (either systematic or idiosyncratic) and other control variables with industry fixed effects. We include year dummies to control for time-specific effects. The regression results are presented in Table 8. The coefficient estimate of asset market beta in column(1) is positive and statistically significant with a magnitude of 0.428 and a t-statistic of 4.11. It implies that a one-standard deviation increase in market beta for firms with CDS data increases the slope of credit spreads by 24 basis points. In column (2), we introduce other firm controls in the regression, and the coefficient estimate of asset market beta increases to 0.505 with a t-statistic of 3.34. The other firm-specific variables that have statistically significant coefficients in most regressions are firm size, book leverage, market-to-book ratio, profit volatility and Merton's distance-to-default measure. All else equal, small, high leverage, high market-to-book ratio, low profit volatility and high default probability firms are associated with high CDS slopes. Next, we introduce the systematic and idiosyncratic component of asset volatility in the regression and the results are reported in column (3). The coefficient estimate of systematic asset volatility is positive and statistically significant, but the coefficient of idiosyncratic asset volatility in column is negative and not statistically significant.

In column (4), we use asset bank beta in the regression, and the coefficient estimate of the asset bank beta is 0.421 with a t-statistic of 2.80. The estimate implies that a one-standard deviation increase in a firm's asset bank beta is associated with a 17 basis point increase in the CDS slope. Quantitatively similar results are obtained when we include asset tail beta in the regression (column (5)). However, the CDS slope is not significantly related with equity beta as shown in column (6).

We test the robust of our finding on the relation between firms' systematic risk and the slope of credit spreads using an alternative measure of the slope of CDS spreads, i.e. the spread difference between 5-year CDS and 1-year CDS. The regression results are presented in Table 10. We are able to replicate our findings using this new measure. In column (1), we include asset market beta without other firm controls in the regression, the coefficient estimate of asset market beta is 0.353 with a t-statistic of 3.93. The estimate implies that a one-standard deviation increase in asset market beta ia associated with a 21 basis point increase in the spread between 5-year and 1-year CDS. In column (2) we introduce other firm controls in the regression, the coefficient estimate of asset market beta is 0.389 with a t-statistic of 3.12. In column (3) we replace asset beta with systematic and idiosyncratic asset volatility, the coefficient estimate of systematic asset volatility is positive and significant, while the coefficient of the idiosyncratic asset volatility is negative, but not significant. Our results are robust to using asset bank beta (column (4)) and asset tail beta (column (5)). The CDS slope is not significantly correlated with equity beta (column (6)).

6 Conclusion

We construct a dynamic capital structure model with optimal maturity choice to explain a number of new facts about relation between debt maturity and systematic risk. First, in cross-section, we find that while firms with high idiosyncratic asset volatility prefer shorter debt maturity, firms with high systematic volatility prefer longer maturity. Second, firms with higher asset beta choose longer maturity, and their maturity structure is relatively stable over the business cycle. In contrast, firms with low beta have significantly shorter debt maturity in a recession. In our model, a firm faces a trade-off in issuing long-term debt. On one hand, since liquidation for firms with high systematic risk is more likely to occur in aggregate bad times, the embedded risk premium raises the expected liquidation costs due to rollover and causes these firms to favor long-term debt. On the other hand, in recessions, higher uncertainty makes the problem of information asymmetry more severe, which raises the costs of issuing long-term debt. Firms with low systematic risk are less concerned about the rollover risk, and choose shorter debt maturity on average. They can also take advantage of the relatively cheaper short-term financing in recessions by reduce their debt maturity more. As a result, the debt maturity for low beta firms is relatively more volatile over the business cycle.

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Table 1: **Summary Statistics**

This table presents summary statistics of firm-level variables in the entire sample and in the sub-sample containing firms with CDS data.

	all firms						firms with CDS					
	mean	std	median	25%	75%	obs	mean	std	median	25%	75%	obs
ldebt1y	0.738	0.284	0.851	0.613	0.953	93,428	0.879	0.147	0.930	0.824	0.988	3,040
ldebt2y	0.609	0.312	0.698	0.386	0.867	78,277	0.795	0.183	0.836	0.697	0.943	2,763
ldebt3y	0.509	0.316	0.559	0.231	0.775	76,622	0.705	0.213	0.736	0.579	0.869	2,766
ldebt4y	0.430	0.307	0.442	0.134	0.682	73,964	0.609	0.231	0.632	0.461	0.777	2,754
ldebt5y	0.356	0.291	0.335	0.064	0.585	70,186	0.509	0.237	0.528	0.346	0.671	2,696
debt mat	4.835	2.563	4.833	2.690	6.870	70,323	6.309	1.870	6.480	5.069	7.629	2,704
mkat	5.577	2.056	5.391	4.027	7.001	91,777	9.340	0.983	9.368	8.598	10.190	3,040
abnearn	0.014	0.236	0.009	-0.038	0.047	84,369	0.019	0.195	0.006	-0.015	0.028	3,032
bklev	0.300	0.170	0.273	0.168	0.400	93,428	0.308	0.152	0.278	0.195	0.391	3,040
mk2bk	1.563	1.120	1.212	0.951	1.719	91,777	1.650	0.766	1.437	1.149	1.888	3,040
assetmat	4.578	4.655	3.093	1.813	5.443	90,054	5.119	4.702	3.632	1.994	6.644	2,902
profitvol	0.063	0.083	0.036	0.019	0.070	79,188	0.032	0.039	0.021	0.012	0.036	3,016
mertondd	5.483	3.950	4.744	2.570	7.558	62,953	7.828	4.879	7.093	4.071	11.000	2,896
asset market beta	0.872	0.627	0.792	0.452	1.193	63,839	0.895	0.585	0.805	0.506	1.200	2,902
asset bank beta	0.506	0.442	0.470	0.231	0.743	63,839	0.501	0.427	0.460	0.241	0.715	2,902
asset tail beta	0.665	0.602	0.614	0.268	1.003	63,536	0.881	0.434	0.819	0.584	1.110	2,901
equity market beta	1.125	0.738	1.067	0.658	1.515	63,839	1.158	0.770	1.016	0.633	1.532	2,902
asset vol	0.381	0.191	0.335	0.254	0.456	63,839	0.292	0.130	0.266	0.201	0.349	2,902
sys asset vol	0.137	0.094	0.120	0.067	0.186	63,839	0.134	0.097	0.110	0.067	0.176	2,902
id asset vol	0.342	0.174	0.299	0.220	0.417	63,839	0.248	0.109	0.227	0.171	0.298	2,902
cds1y (%)							1.603	6.347	0.378	0.139	1.103	3,040
cds3y (%)							1.872	5.286	0.610	0.272	1.702	3,033
cds5y (%)							2.105	4.892	0.820	0.395	2.144	3,034
cds10y (%)							2.207	4.282	1.049	0.559	2.472	3,040
cds10y - cds1y (%)							0.604	2.686	0.503	0.284	1.015	3,040
cds5y - cds1y (%)							0.500	2.090	0.328	0.172	0.741	3,034

Table 2: **Long-Term Debt Share: Systematic and Idiosyncratic Risk**

This table presents regressions of the fraction of debt that matures in more than 3 years on firm-specific variables: firm risk, firm size, abnormal earning, book leverage, market-to-book ratio, asset maturity, profit volatility, and Merton's distance-to-default. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	Fama-MacBeth					Panel Regression				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
market beta	0.011	0.085***	0.101***		0.045***	0.023***	0.036***			
	(1.29)	(10.95)	(10.98)		(7.32)	(6.20)	(8.43)			
asset vol		-0.555***	-0.542***							
		(-24.80)	(-22.15)							
sys asset vol				0.308***				0.279***		
				(8.95)				(9.91)		
id asset vol				-0.555***				-0.051***		
				(-34.11)				(-3.31)		
bank beta									0.037***	
									(5.95)	
tail beta										0.032***
										(9.84)
mkat					0.048***		0.048***	0.047***	0.049***	0.047***
					(13.44)		(17.72)	(17.10)	(17.88)	(17.49)
abnearn					0.026***		0.020***	0.018***	0.022***	0.023***
					(2.76)		(3.55)	(3.27)	(3.95)	(4.07)
bklev			0.258***		0.285***		0.281***	0.276***	0.261***	0.263***
			(6.15)		(9.34)		(14.63)	(14.88)	(14.04)	(14.02)
mk2bk					-0.049***		-0.033***	-0.031***	-0.029***	-0.031***
					(-8.45)		(-5.77)	(-5.41)	(-5.00)	(-5.52)
assetmat					0.009***		0.007***	0.007***	0.007***	0.007***
					(14.99)		(6.71)	(6.86)	(6.72)	(6.69)
profitvol					-0.316***		-0.297***	-0.282***	-0.290***	-0.283***
					(-4.69)		(-6.02)	(-5.89)	(-6.02)	(-5.91)
mertondd					0.006***		0.005***	0.005***	0.005***	0.005***
					(6.48)		(5.10)	(4.40)	(4.09)	(4.11)
Constant	0.532***	0.674***	0.580***	0.683***	0.137***	0.527***	0.156***	0.169***	0.166***	0.176***
	(33.18)	(48.19)	(26.39)	(52.20)	(3.39)	(67.52)	(9.40)	(9.38)	(9.85)	(10.22)
Industry Fixed-Effect	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	54,637	54,637	54,007	54,637	46,978	54,637	46,978	46,978	46,978	46,818
R^2	0.004	0.076	0.095	0.077	0.211	0.025	0.172	0.172	0.170	0.170

Table 3: **Long-Term Debt Share: Impact of Business Cycles**

This table presents regression results of the impact of business cycles on long-term debt share. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
rec	-0.034***	-0.036***	-0.048***	-0.053***	-0.026***	-0.029***	-0.033***	-0.036***
	(-4.93)	(-5.49)	(-4.99)	(-6.02)	(-4.40)	(-4.39)	(-6.25)	(-6.33)
market beta	0.027***	0.040***						
	(7.03)	(9.00)						
market beta × rec	0.021***	0.020***						
	(2.65)	(2.80)						
sys asset vol			0.313***	0.245***				
			(14.70)	(9.65)				
sys asset vol × rec			0.100**	0.092**				
			(2.23)	(2.05)				
id asset vol			-0.488***	-0.083***				
			(-28.94)	(-5.70)				
id asset vol × rec			0.069**	0.068***				
			(2.48)	(2.64)				
bank beta					0.042***	0.041***		
					(7.29)	(6.80)		
bank beta × rec					0.025**	0.022*		
					(2.47)	(1.93)		
tail beta							0.061***	0.034***
							(15.69)	(10.05)
tail beta × rec							0.025***	0.023***
							(3.55)	(3.26)
Quadratic Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	No	Yes	No	Yes	No	Yes	No	Yes
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	54,637	46,978	54,637	46,978	54,637	46,978	54,403	46,818
R^2	0.017	0.165	0.070	0.164	0.017	0.162	0.029	0.163

Table 4: **Firm Characteristics and the Impact of Business Cycles**

This table presents regression results of the impact of business cycles on long-term debt shares with the impact of business cycles to depending on other firm characteristics in addition to asset beta. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
rec	0.014	0.017	0.014	0.026	0.022	0.026
	(0.76)	(0.94)	(0.74)	(1.42)	(1.24)	(1.39)
market beta	0.041***			0.037***		
	(9.17)			(8.06)		
market beta × rec	0.014**			0.016**		
	(2.07)			(2.24)		
bank beta		0.041***			0.038***	
		(6.93)			(6.59)	
bank beta × rec		0.015			0.027***	
		(1.42)			(2.66)	
tail beta			0.034***			0.031***
			(9.74)			(8.69)
tail beta × rec			0.025***			0.028***
			(3.34)			(3.60)
mkat	0.048***	0.048***	0.047***	0.046***	0.047***	0.045***
	(17.26)	(17.23)	(16.88)	(18.00)	(18.22)	(17.76)
mkat × rec	-0.005**	-0.005**	-0.007***	-0.004*	-0.004*	-0.006**
	(-2.49)	(-2.43)	(-3.16)	(-1.91)	(-1.82)	(-2.58)
abnearn	0.011*	0.013**	0.015**	0.010	0.012*	0.013**
	(1.83)	(2.14)	(2.36)	(1.56)	(1.92)	(2.06)
abnearn × rec	0.056**	0.053**	0.050**	0.075***	0.070***	0.068***
	(2.53)	(2.40)	(2.24)	(3.38)	(3.15)	(3.09)
bklev	0.299***	0.279***	0.278***	0.296***	0.277***	0.277***
	(15.03)	(14.56)	(14.23)	(14.98)	(14.68)	(14.36)
bklev × rec	-0.062**	-0.073**	-0.055*	-0.082***	-0.087***	-0.075**
	(-1.99)	(-2.45)	(-1.73)	(-2.68)	(-2.92)	(-2.37)
mk2bk	-0.037***	-0.033***	-0.035***	-0.037***	-0.033***	-0.035***
	(-5.87)	(-5.12)	(-5.63)	(-5.61)	(-4.89)	(-5.36)
mk2bk × rec	0.016*	0.021**	0.014*	0.012	0.017**	0.010
	(1.90)	(2.51)	(1.66)	(1.50)	(2.07)	(1.17)
assetmat	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***
	(6.66)	(6.64)	(6.64)	(6.74)	(6.72)	(6.73)
assetmat × rec	0.001	0.001	0.001	0.001	0.001	0.001
	(0.82)	(0.89)	(0.77)	(1.25)	(1.27)	(1.18)
profitvol	-0.287***	-0.280***	-0.269***	-0.312***	-0.305***	-0.295***
	(-5.65)	(-5.67)	(-5.47)	(-6.41)	(-6.46)	(-6.25)
profitvol × rec	0.038	0.037	0.029	0.014	0.019	0.007
	(0.44)	(0.44)	(0.33)	(0.17)	(0.23)	(0.08)
mertondd	0.007***	0.007***	0.006***	0.007***	0.007***	0.006***
	(7.27)	(6.32)	(6.14)	(6.87)	(5.89)	(5.84)
mertondd × rec	-0.004**	-0.004**	-0.003*	-0.006***	-0.006***	-0.005***
	(-2.34)	(-2.54)	(-1.95)	(-3.96)	(-3.93)	(-3.52)
Quadratic Trend	Yes	Yes	Yes	No	No	No
Aggregate Trend	No	No	No	Yes	Yes	Yes
Industry-Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	46,978	46,978	46,818	46,978	46,978	46,818
R^2	0.166	0.163	0.164	0.165	0.163	0.163

Table 5: **Baseline model parameters.** This table contains the parameters used in the baseline model and the results on capital structure and credit spreads. Parameters that do not vary across the states include: $\sigma_f = 0.20$, $\lambda = 0.08$, $\alpha = 0.65$, $\tau = 0.2$, $f(0.3) = 4.5$. The initial capital structure choices are determined during an expansion ($s_0 = G$).

A. Baseline parameters

	state G	state B
$\pi^{\mathbb{P}}_{ss'}$	0.1	0.5
$\kappa(s, s')$	$\ln 3$	$-\ln 3$
$\mu_{\mathbb{P}}(s)$	0.043	0.022
$r(s)$	0.045	0.024
$\eta(s)$	0.17	0.43
$\sigma_m(s)$	0.124	0.151
$h(4)$	0.1 bps	1.5 bps
$h(7)$	5 bps	16 bps

Table 6: **Baseline model results** This table summarizes results from the baseline calibration

	state G	state B
Leverage (D/V)	35.6%	39.4%
Initial interest coverage (y_0/C)	2.3	2.3
Debt maturity (m)	5.2	4.5
5 year default rate	0.8%	1.3%
10 year default rate	5.5%	6.6%
5 year credit spread	52.4 bps	101.7 bps
10 year credit spread	162.6 bps	223.2 bps
Asset beta	0.81	0.51
Average asset beta	0.76	0.76

Table 7: **Comparative statics for default boundaries.** This table shows (i) default boundaries (as a fraction of the initial cashflow) and (ii) 5 year cumulative default probabilities under the physical measure (%, enclosed in square brackets). Both (i) and (ii) are conditional values which depends on the initial state. These values are reported for combinations of asset beta, leverage and maturity. High (low) leverage corresponds to an initial interest coverage (y_0/C) of 1.5 (4.5). Maturities are fixed across states with long (short) maturity set to 7 (3) years. The total volatility for both high and low beta firms are fixed at baseline levels, with the high and low beta firms having idiosyncratic volatilities of 10% and 20% respectively. The average asset beta corresponding to the optimal capital structure is 1.26 for the high beta firm and 0.76 for the low beta firm.

	high asset beta		low asset beta	
	state G	state B	state G	state B
high leverage long maturity	0.551 [21.6]	0.614 [27.1]	0.390 [5.6]	0.426 [7.6]
high leverage short maturity	0.624 [31.6]	0.699 [39.3]	0.427 [8.1]	0.466 [10.7]
low leverage long maturity	0.184 [0.1]	0.205 [0.2]	0.130 [0.0]	0.142 [0.0]
low leverage short maturity	0.208 [0.2]	0.233 [0.4]	0.142 [0.0]	0.155 [0.0]

Table 8: **Slope of CDS Spreads: Systematic and Idiosyncratic Risk**

This table presents cross-sectional regressions of the slope of CDS spreads, measured by the spread difference between 10-year and 1-year CDS, on firm-specific variables: risk measure, firm age, log market value, profit, book leverage, market-to-book ratio, asset maturity, asset volatility, and Merton's distance-to-default. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
market beta	0.428***	0.505***				
	(4.11)	(3.34)				
sys asset vol			3.579***			
			(3.16)			
id asset vol			-2.834			
			(-1.55)			
bank beta				0.421***		
				(2.80)		
tail beta					0.382**	
					(2.54)	
equity beta						-0.066
						(-0.56)
mkat		-0.207***	-0.234***	-0.209***	-0.198***	-0.208***
		(-3.82)	(-3.74)	(-3.76)	(-3.65)	(-3.72)
abnearn		0.412	0.437	0.505	0.526	0.593
		(0.93)	(1.07)	(1.13)	(1.18)	(1.26)
bklev		1.274***	0.759	0.932**	1.126***	0.845*
		(3.11)	(1.33)	(2.04)	(2.70)	(1.76)
mk2bk		0.163***	0.230***	0.213***	0.177***	0.207***
		(3.14)	(3.15)	(4.23)	(3.21)	(4.00)
assetmat		-0.007	0.001	-0.011	-0.006	-0.009
		(-0.45)	(0.05)	(-0.74)	(-0.35)	(-0.61)
profitvol		-6.529*	-4.751*	-5.794*	-5.291	-4.601
		(-1.88)	(-1.73)	(-1.68)	(-1.55)	(-1.50)
mertondd		0.006	-0.022	-0.008	-0.010	-0.019
		(0.27)	(-0.92)	(-0.37)	(-0.52)	(-1.29)
Constant	-0.262**	1.144*	2.315*	1.333**	1.130*	1.646**
	(-2.02)	(1.86)	(1.97)	(2.17)	(1.90)	(2.41)
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,412	2,231	2,231	2,231	2,231	2,231
R^2	0.069	0.084	0.094	0.079	0.079	0.075

Appendix

A Data

B Model Solution

Given capital structure $(P, \lambda = \frac{C}{P}, \mathbf{m} = (m_G, m_B)')$, external financing costs $\ell_D(\sigma_f, m, ss)$ and bankruptcy boundaries $\{y_B(s)\}_{s\in\{G,B\}}$, debt value at issue, $\bar{d}(y,s)$, is characterized by the following system of ODEs:

$$\begin{aligned} \left[r(s) + \ell_D(\sigma_f, m, s) + \frac{1}{m_s}\right]\bar{d}(y,s) &= C + \frac{1}{m_s}P + \mu(s)y\frac{\partial}{\partial y}\bar{d}(y,s) + \frac{1}{2}\sigma(s)^2y^2\frac{\partial^2}{\partial y^2}\bar{d}(y,s) \\ &\quad + \sum_{s'\neq s}\pi_{ss'}\left[\bar{d}(y,s') - \bar{d}(y,s)\right] \\ \bar{d}(y_B(s),s) &= \alpha(s)v^*(s)y_B(s) \end{aligned}$$

Similarly, the value of equity, $E(y,s)$, is characterized by

$$\begin{aligned} r(s)E(y,s) &= (1-\tau)(y-C) + \frac{1}{m_s}\left[\bar{d}(y,s) - P\right] \\ &\quad + \mu(s)y\frac{\partial}{\partial y}E(y,s) + \frac{1}{2}\sigma(s)^2y^2\frac{\partial^2}{\partial y^2}E(y,s) \\ &\quad + \sum_{s'\neq s}\pi_{ss'}\left[E(y,s') - E(y,s)\right] \\ E(y_B(s),s) &= 0 \\ \frac{\partial}{\partial y}E(y_B(s),s) &= 0 \end{aligned}$$

In the solutions to the above equations, we will work in terms of $x := \ln y$. State by state debt value $\mathbf{d}(x) = \left(\bar{d}(x,G), \bar{d}(x,B)\right)'$ is given by

$$\mathbf{d}(x) = \mathbf{d}_0 + \sum_{k\in\{G,B\}}\omega_{D,k}\mathbf{d}_{1,k}e^{-\lambda_{D,k}x}$$

where

$$\begin{aligned}
\mathbf{d}_0 &= \mathbf{W}_D^{-1}\left(C\mathbf{1} + \mathbf{P}./\mathbf{m}\right) \\
\mathbf{W}_D &= \left(W_{ij}^D\right),\, W_{ii}^D = r(i) + \ell_D(\sigma_f, m_i; i) + \frac{1}{m_i} + \sum_{k\neq i}\pi_{ik},\, W_{ij}^D = -\pi_{ij}\,(j \neq i)
\end{aligned}$$

where ./ denotes element-wise division and $\{(\lambda_{D,k}, \mathbf{d}_{1,k})\}_{k\in\{G,B\}}$ are the positive eigenvalue solutions to the following quadratic eigenvalue problem[8]:

$$\begin{aligned}
\mathbf{W}_D\mathbf{z} &= -\lambda\mathbf{U}\mathbf{z} + \lambda^2\mathbf{V}\mathbf{z} \\
\mathbf{U} &= \operatorname{diag}\left(\mu(G) - \frac{1}{2}\sigma(G)^2, \mu(B) - \frac{1}{2}\sigma(B)^2\right) \\
\mathbf{V} &= \operatorname{diag}\left(\frac{1}{2}\sigma(G)^2, \frac{1}{2}\sigma(B)^2\right)
\end{aligned}$$

The weights, $\{\omega_{D,k}\}_{k\in\{G,B\}}$, are chosen to match bankruptcy conditions:

$$\omega_D = \begin{bmatrix} \mathbf{d}_{1,G}\odot e^{-\lambda_{D,G}\mathbf{x}_B} & \mathbf{d}_{1,B}\odot e^{-\lambda_{D,|\mathcal{S}|}\mathbf{x}_B} \end{bmatrix}^{-1}\left(\alpha\odot\mathbf{v}^*\odot e^{\mathbf{x}_B} - \mathbf{d}_0\right)$$

where $\odot$ denotes element-wise multiplication and exponentiation of vectors refer to element-wise exponentiation. Equity value is given by

$$\mathbf{E}(x) = \mathbf{E}_0 + \mathbf{E}_1 e^x + \sum_{k\in\{G,B\}}\mathbf{E}_{D,k}e^{-\lambda_{D,k}x} + \sum_{k\in\{G,B\}}\omega_{E,k}\mathbf{E}_{E,k}e^{-\lambda_{E,k}x}$$

where

$$\begin{aligned}
\mathbf{W}_E &= \left(W_{ij}^E\right),\, W_{ii}^E = r(i) + \sum_{k\neq i}\pi_{ik},\, W_{ij}^E = -\pi_{ij}\,(j\neq i) \\
\mathbf{E}_0 &= \mathbf{W}_E^{-1}\left[\left(\mathbf{d}_0 - P\mathbf{1}\right)./\mathbf{m} - (1-\tau)C\mathbf{1}\right] \\
\mathbf{E}_1 &= \left(\mathbf{W}_E - \mathbf{U} - \mathbf{V}\right)^{-1}\left(\mathbf{1} - \mathbf{t}\right) \\
\mathbf{E}_{D,k} &= \omega_{D,k}\left(\mathbf{W}_E + \lambda_{D,k}\mathbf{U} - \lambda_{D,k}^2\mathbf{V}\right)^{-1}\left(\mathbf{d}_{1,k}./\mathbf{m}\right)
\end{aligned}$$

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[8] this can be solved in MATLAB by using the `polyeig` function

and $\{\lambda_{E,k}, \mathbf{E}_{E,k}\}_{k\in\{G,B\}}$ are the positive eigenvalue solutions to the following quadratic eigenvalue problem:

$$\mathbf{W}_E\mathbf{z} = -\lambda\mathbf{U}\mathbf{z} + \lambda^2\mathbf{V}\mathbf{z}$$

Finally, $\omega_E = (\omega_{E,G}, \omega_{E,B})'$ and $\mathbf{x}_B = (x_B(G), x_B(B))'$ are chosen to satisfy continuity and smooth pasting conditions for equity value at the default boundary:

$$\begin{array}{rcl}
\omega_E & = & -\left[\begin{array}{cc} \mathbf{E}_{E,G}\odot e^{-\lambda_{E,G}\mathbf{x}_B} & \mathbf{E}_{E,B}\odot e^{-\lambda_{E,B}\mathbf{x}_B}\end{array}\right]^{-1}\left(\mathbf{E}_0 + \mathbf{E}_1\odot e^{\mathbf{x}_B} + \mathbf{b}^{(1)}\right) \\
\mathbf{b}^{(1)} & = & \left(b_i^{(1)}\right),\ b_i^{(1)} = \left(\begin{array}{cc} E_{D,G}(i) & E_{D,B}(i)\end{array}\right)e^{-\vec{\lambda}_D x_B(i)} \\
\mathbf{0} & = & \mathbf{E}_1\odot e^{\mathbf{x_B}} - \mathbf{b}^{(2)} - \mathbf{b}^{(3)} \\
\mathbf{b}^{(2)} & = & \left(b_i^{(2)}\right),\ b_i^{(2)} = \left[\begin{array}{cc} \lambda_{D,G}\mathbf{E}_{D,G}(i) & \lambda_{D,B}\mathbf{E}_{D,B}(i)\end{array}\right]e^{-\vec{\lambda}_D x_B(i)} \\
\mathbf{b}^{(3)} & = & \left(b_i^{(3)}\right),\ b_i^{(3)} = \left[\begin{array}{cc} \lambda_{E,G}\omega_{E,G}\mathbf{E}_{E,G}(i) & \lambda_{E,B}\omega_{E,B}\mathbf{E}_{E,B}(i)\end{array}\right]e^{-\vec{\lambda}_E x_B(i)}
\end{array}$$

Finally, we include details for calculating asset betas. We do so by specifying the market exogenously and then calculating the model implied market betas.

Specifying the market. We first specify market returns as a levered claim on consumption. In reduced form, dividends follow

$$\frac{dD_t}{D_t} = \mu_D^{\mathcal{P}}(s_t)dt + \sigma_D(s_t)dZ_t^m$$

The value of the dividend stream is then given by

$$V_D(D_t, s_t) = D_t v_D(s_t)$$

where the vector v_D is known in closed form. Market returns are then given as

$$\frac{dV_D}{V_D} = ...dt + \sigma_D(s_{t-})dZ_t^m + \sum_{s'\neq s_t}\left(\frac{v_D(s')}{v_D(s_{t-})} - 1\right)dN_t^{s_{t-}\to s'}$$

Excess returns. Now let V be any asset[9] (e.g. V can be debt or equity), then we have

$$\begin{aligned} dV(y_t, s_t) &= y_t V_y(y_t, s_{t-}) \left(\mu_{\mathcal{P}}(s_{t-})dt + \sigma_f(s_{t-})dZ_t^f + \sigma_m(s_{t-})dZ_t^m \right) \\ &\quad + \sum_{s' \neq s_{t-}} \left[V(y_t, s') - V(y_t, s_{t-}) \right] dN_t^{s_{t-} \to s'} \end{aligned}$$

Given the pricing kernel

$$\frac{d\pi_t}{\pi_{t-}} = -r(s_{t-})dt - \eta(s_{t-})dZ_t^m + \sum_{s' \neq s_{t-1}} \left(e^{\kappa(s_{t-}, s')} - 1 \right) dM_t^{s_{t-} \to s'}$$

We can calculate excess returns as

$$\begin{aligned} \mathbb{E}_t \left[\frac{dV_t}{V_{t-}} + \frac{d\pi_t}{\pi_{t-}} \right] &= -\frac{d\langle \pi, V \rangle_t}{\pi_{t-} V_{t-}} \\ &= \left\{ \frac{y_t V_y(y_t, s_{t-}) \sigma_m(s_{t-}) \eta(s_{t-})}{V(y_t, s_{t-})} \right. \\ &\quad \left. - \sum_{s' \neq s_{t-}} \pi_{s_{t-} s'} \left(e^{\kappa(s_{t-}, s')} - 1 \right) \left(\frac{V(y_t, s')}{V(y_t, s_{t-})} - 1 \right) \right\} dt \end{aligned}$$

Market betas. The market beta of V is given by

$$\begin{aligned} \beta_V(y, s) &= \frac{\mathbb{E}_t \frac{d\langle V, V_D \rangle_t}{V_{t-} V_{D,t-}}}{\mathbb{E}_t \frac{d\langle V_D \rangle_t}{V_{D,t-}^2}} \\ &= \frac{\frac{y V_y(y,s) \sigma_m(s) \sigma_D(s)}{V(y,s)} + \sum_{s' \neq s} \pi_{ss'} \left(\frac{V(y,s')}{V(y,s)} - 1 \right) \left(\frac{v_D(s')}{v_D(s)} - 1 \right)}{\sigma_D^2 + \sum_{s' \neq s} \pi_{ss'} \left(\frac{v_D(s')}{v_D(s)} - 1 \right)^2} \end{aligned}$$

Finally, we calculate asset betas as the weighted some of debt and equity betas, with the weights given by the debt and equity share of the firm value respectively.

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[9] more precisely, the gains process associated with any asset.

C Variable Definition and Data Sources

tdebt (total debt): debt in current liability (*dlc*) + long-term debt (*dltt*). Data source: COMPUSTAT Annual Industrial file.

*ldebt*1*y* (the percentage of total debt that matures in more than 1 year): long-term debt (*dltt*) / *tdebt*. Data source: COMPUSTAT Annual Industrial file.

*ldebt*2*y* (the percentage of total debt that matures in more than 2 years): $(dltt - dd2)$ / *tdebt*. Data source: COMPUSTAT Annual Industrial file.

*ldebt*3*y* (the percentage of total debt that matures in more than 3 years): $(dltt - dd2 - dd3)$ / *tdebt*. Data source: COMPUSTAT Annual Industrial file.

*ldebt*4*y* (the percentage of total debt that matures in more than 4 years): $(dltt - dd2 - dd3 - dd4)$ / *tdebt*. Data source: COMPUSTAT Annual Industrial file.

*ldebt*5*y* (the percentage of total debt that matures in more than 5 years): $(dltt - dd2 - dd3 - dd4 - dd5)$ / *tdebt*. Data source: COMPUSTAT Annual Industrial file.

mke (market value of equity): share price ($prcc_f$) × common share outstanding (*csho*). Data source: COMPUSTAT Annual Industrial file.

bke (book value of equity): stockholders' equity (shareholder's equity (*seq*), if not available, common equity (*ceq*) + par value of preferred shares (*pstk*), if not available, total asset (*at*) - total liability (*lt*)) + deferred tax and investment tax credit (*txditc*) - book value of preferred shares (redemption value (*pstkrv*), if not available, liquidation value (*pstkl*), if not available, par value (*pstk*)). Data source: COMPUSTAT Annual Industrial file.

mkat (market value of total assets): (the market value of equity (*mke*) + the book value of total assets (*at*) - the book value of equity (*bke*) / GDP deflator, in logs. Data source: COMPUSTAT Annual Industrial file.

abnearn (abnormal earning): (earnings in year $t + 1$ (*ibadj*) - earnings in year t) / (share price ($prcc_f$) × outstanding shares (*cshpri*) in year t). Data source: COMPUSTAT Annual Industrial file.

bklev (book leverage): total debt (debt in current liability (*dlc*) + long-term debt (*dltt*)) / assets (*at*). Data source: COMPUSTAT Annual Industrial file.

mk2bk (market-to-book ratio): the market value of total assets (*mkat*, not in logs) / the book value of total assets (*at*). Data source: COMPUSTAT Annual Industrial file.
profitvol (profit volatility): volatility of past 5 years of profit growth (operating income before depreciation in year t (*oibdp*) - operating income before depreciation in year $t-1$)) / assets (*at*). Data source: COMPUSTAT Annual Industrial file.
assetmat (asset maturity): book value-weighted average of the maturities of property, plant and equipment and current assets, computed as (gross property, plant, and equipment (*ppent*)/total assets (current assets (*act*) + *ppent*) × (gross property, plant, and equipment (*ppent*) /depreciation expense (*dp*)) + (current assets (*act*)/total assets (current assets (*act*) + *ppent*)) × (current assets (*act*)/cost of goods sold (*cogs*)). Data source: COMPUSTAT Annual Industrial file.

In Table 9, we examine the correlation among various betas that we use in this study. We also include asset variance proxies, i.e. *asset vol*, *sys asset vol*, and *id asset vol*, and Merton's distance-to-default measure (*mertondd*). For firms in the entire sample, our beta proxies are highly correlated. They are also positively correlated with both systematic and idiosyncratic components of asset volatility. As expected, Merton's distance-to-default measure is negatively correlated with idiosyncratic asset volatility. But its correlation with asset betas is much smaller, probably reflecting the fact that high beta firms choose low leverage to reduce default probability. However, for firms with CDS data, Merton's distance-to-default measure is negatively correlated to asset market betas with a large magnitude (-0.25).

C.1 Asset Beta

To compute a firm's asset beta, we assume the total value of the firm follows:

$$dV = \mu V dt + \sigma_V V dW,$$

where V is the value of firm's assets, with an instantaneous drift μ, and an instantaneous volatility σ_V. W is the standard Wiener process.

Assuming that the firm issued one discount bond maturing in T period, the value of equity is given by the Black and Scholes (1973) formula for a call option:

$$E = VN(d_1) + Fe^{-rT}N(d_2), \tag{17}$$

where E is the market value of equity, F is the face value of the debt, r is the instantaneous risk-free interest rate, $N(.)$ is the accumulative standard normal distribution function, d_1 is given by

$$d_1 = \frac{\ln(V/F) + (r + \frac{1}{2}\sigma_V^2)T}{\sigma_V\sqrt{T}},$$

and

$$d_2 = d_1 - \sigma_V\sqrt{T}.$$

Under Mertons assumptions that the value of equity is a function of the value of the firm and time, using Itos lemma we obtain

$$\sigma_E = \frac{V}{E}\frac{\partial E}{\partial V}\sigma_V = \frac{V}{E}N(d_1)\sigma_V. \tag{18}$$

To implement the model, we need to simultaneously solve equations 17 and 18 to recover firm asset value, V, and asset volatility, σ_V. Following Vassalou and Xing (2004) and Bharath and Shunway (2008), we adopt an iterative procedure as follows. First, equity volatility σ_E is estimated using past 60 months (at least 36 months) of equity returns. Monthly risk-free rates are obtained from CRSP. To compute the face value of debt for each firm, we use the firms' total book value of short-term debt plus one-half of the book value of long-term debt. To avoid problems related to reporting delays, we lag the book value of debt by 4 months for each fiscal year. Debt maturity T is set at 1 year. Then, we propose an initial value for asset volatility, σ_v, which is computed as

$$\sigma_V \;=\; \sigma_E \frac{E}{E+F}.$$

Using equation 17, and for each month of the past 36 months, we compute firm asset value V using E as the market value of equity of that month. We then calculate the implied log return on assets each month and use that returns series to generate new estimates of σ_V and μ. We iterate on σ_V in this manner until it converges. Our tolerance level for convergence is 10^{-4}.

Once obtaining estimates of V, σ_V, and μ, we can compute unlevered asset beta using:

$$\beta_V \;=\; \beta_E \frac{E}{V} \frac{1}{N(d_1)},$$

and Merton's distance to default as follows:

$$mertondd \;=\; \frac{\ln(V/F) + (\mu - \frac{1}{2}\sigma_V^2)T}{\sigma\sqrt{T}}.$$

Furthermore, using equation 18, we can compute the systematic component of asset variance as follows:

$$\sigma^2_{V,sys} \;=\; \left(\frac{E}{V}\frac{1}{N(d_1)}\right)^2 \sigma^2_{E,sys},$$

where $\sigma^2_{E,sys}$ is the systematic component of equity variance. Then the idiosyncratic component of asset variance is the difference between the asset variance and the systematic component of asset variance:

$$\sigma^2_{V,id} \;=\; \sigma^2_V - \sigma^2_{V,sys}.$$

As alternative proxies for firms' exposure to systematic risk, we also compute a firm's "bank beta" based on a firm's exposure to banking sector's risk. We first compute "equity bank betas" using past 36 months of the firm's equity returns and portfolio returns of the financial sector from the Fama-French 48 industrial portfolio returns file. As before, we require that a firm has 36 months of past equity returns. We then back out "asset bank betas" using the Merton model. In addition, a firm's exposure to systematic risks matters most on the downside. We follow Acharya, Almeida, and Campello (2010) and compute a firm's tail beta to capture the firm's exposure to large negative shocks to the market factor. As before, we first compute a "equity tail beta" as the average percentage loss suffered by a firm's equity when the market return is in its 5% days of the previous year. We then back out the "asset tail beta" using the Merton model. Furthermore, we attempt to tease out the importance of both systematic and idiosyncratic risk in corporate debt maturity management. Using a firm's equity systematic volatility and its asset volatility, we can compute the systematic and idiosyncratic component of the firm's asset volatility based on the Merton model. We decompose firms' total risk using returns to the market factor as the proxy for systematic risk.

D Robustness Checks

D.1 Alternative Debt Maturity Measures

We use the proportion of long-term debt that matures in more than 3 years as a proxy for debt maturity in the previous section. COMPUSTAT provides the information on the amount of debt that matures in years one through five, and more than five years. The numerical debt maturity we constructed in the previous section uses all the information on the distribution of a firm's debt structure, although we have to make an assumption on the actual maturity of debt in each maturity category. We replace the long-term debt shares with the numerical debt maturity in the regression analysis, and examine whether our findings of the relationship between debt maturity and asset beta is robust to this alternative debt maturity measures.

First, we obtain very similar cross-sectional results using the numerical estimate of debt maturity in the regression. The results are presented in Table Table 11. The coefficient estimate of asset market beta in column(1) is positive but not statistically significant with a magnitude of 0.118. We introduce total asset volatility in column (2), and the coefficient estimate of asset market beta increases to 0.715 with a t-statistic of 7.86. The estimated coefficient suggests that a one-standard deviation increase in asset beta lengthens firms' debt maturity by about 5.4 months, which is about 18% of the standard deviation of numerical debt maturity estimates. In column (3), we add book leverage in the regression, and the coefficient estimate of asset beta further increases to 0.857, implying that a one-standard deviation increase in asset beta lengthens firms' debt maturity by 6.4 months. In column (4), we include firms' systematic and idiosyncratic asset volatility computed based on asset market beta. The coefficient of the systematic asset volatility is positively and statistically significant, where the coefficient estimate of the idiosyncratic asset volatility is negative and statistically significant. In column (5), we include asset beta and firm controls in the regression, the coefficient estimate of asset beta is 0.365, suggesting a one-standard deviation increase in asset beta lengthens debt maturity by 2.7 months.

We obtain very similar results in column (6) - (8) when we use panel regressions with industry and year fixed effects. Our results is also robust to using asset bank beta (column(9)) and asset tail beta (column(10)) as alternative measures of systematic risk.

Table Table 12 reports the regression results of the impact of business cycles on debt maturity, and these results are similar to those using long-term debt shares (Table Table 3). In column (1), we introduce a recession dummy, asset market beta and their interaction term in the regression. The coefficient estimate of the recession dummy is -0.317 with a t-statistic of -5.25, and the coefficient estimate of the interaction term is 0.140 with a t-statistic of 1.94. These estimates imply that the debt maturity of a firm with asset market beta one-standard deviation below the average declines by 3.4 months in recessions, whereas the debt maturity of a firm with asset market beta one-standard deviation above the average declines by 1.3 month in recessions. Quantitative similar results are obtained using systematic and idiosyncratic asset volatility in the regression (column (3) and (4)). The results is also robust to using asset bank beta (column (5) and (6)) and asset tail beta (column (7) and (8)) to measure firms' systematic risk.

To investigate whether our finding that firms with high systematic risk have longer and more stable debt maturities depends on the 2008 financial crisis, we run regressions using data in a sub-sample periods: 1974–2006. Excluding the last four years (2007-2010) of data enable us to examine whether our results are driven by the unprecedented financial crisis since the Great Depression in the 1930s. The results using long-term debt share and numerical debt maturity measures are presented in Table Table 13. We obtain very similar and slightly more significant results by excluding the last four years of data. Coefficient estimates for both the recession dummy, asset betas and their interaction terms are statistically significant in all specifications. Worsening macroeconomic conditions are associated with shortening debt maturities and high exposure to systematic risk are associated with long debt maturities. In addition, the negative relation between the impact of business cycles on debt maturity and firms' asset betas that we find in the entire sample also exist in the sub-sample period. In fact, all the interaction terms between various asset betas and macroeconomic variables are statistically significant across all specifications. The results show that a firm with high systematic risk exposure has a more stable debt maturity over the business cycles.

To further examine the robustness of our results to different measures of debt maturity, we use the percentage of firms' total debt that matures in more than 1 year, 2 years, 4 years, and 5 years as maturity proxies in the regression. The results are presented in Table Table 14. First, we find a similar impact of macroeconomic conditions and asset beta on various long-term debt share measures. Worsening macroeconomic conditions and lower asset betas are associated with shorter debt maturities. Second, high systematic risk firms reduce their debt maturities more from expansions to recessions than low systematic risk firms. Last, the coefficient estimates of the interaction between asset beta and the recession dummy are not always statistically significant for when we measure debt maturity using the proportion of long-term debt that matures in more than 4 year or 5 years. The results seem to suggest that, from expansions to recessions, firms debt maturity decisions are more sensitive to their systematic risk when they consider the proportion of debt that matures in less than 3 years than the proportion of debt that matures in more than 4 years.

D.2 Firm Characteristics and Trend Effect

In the previous section, we use either a quadratic or an aggregate trend to control for the trend effect. We also assume the trend effect is the same for all firms. As shown in Greenwood, Hanson, and Stein (2010), firm characteristics play an important role in cross-sectional responses to shocks to the aggregate trend. To study whether our results on the impact of business cycles on debt maturity is robust to our assumption, we allow the impact of the aggregate trend on long-term debt share depends on firm characteristics. In the regressions, we include the aggregate trend extracted from the aggregate long-term debt share using the HP filter and the interaction terms between the aggregate trend and firm controls in the panel regressions. The results are reported in Table Table 15. First, using the aggregate trend generates quantitatively similar results (column (1), (3), and (5)) to those using a quadratic time trend. Second, our finding of a more stable debt maturity over business cycles for high systematic risk firms is robust to allowing the loadings of debt maturity depend on firms characteristics. Finally, all else equal, small, low leverage, low profit volatility firms are more sensitive to shocks to the aggregate trend.

D.3 Regression Results of Robustness Checks

Table 9: **Correlation: Risk Measures**

This table presents correlation coefficient of various risk measures for firms in the entire sample and in the sub-sample containing firms with CDS data.

	all firms (observations = 62,658)						
	market beta	bank beta	tail beta	equity beta	asset vol	sys vol	id vol
bank beta	0.714						
tail beta	0.464	0.334					
equity beta	0.915	0.667	0.371				
asset vol	0.409	0.184	0.171	0.346			
sys vol	0.869	0.669	0.420	0.795	0.496		
id vol	0.246	0.048	0.087	0.197	0.961	0.303	
mertondd	0.035	0.038	0.156	-0.187	-0.399	-0.069	-0.431
	firms with CDS (observations = 2,895)						
	market beta	bank beta	tail beta	equity beta	asset vol	sys vol	id vol
bank beta	0.610						
tail beta	0.591	0.249					
equity beta	0.892	0.578	0.447				
asset vol	0.524	0.335	0.335	0.513			
sys vol	0.802	0.567	0.474	0.745	0.701		
id vol	0.263	0.127	0.195	0.280	0.905	0.371	
mertondd	-0.255	-0.240	-0.045	-0.479	-0.609	-0.432	-0.562

Table 10: **Alternative Measure of the Slope of CDS Spreads**

This table presents cross-sectional regressions of the slope of CDS spreads, measured by the spread difference between 5-year and 1-year CDS, on firm-specific variables: risk measure, firm age, log market value, profit, book leverage, market-to-book ratio, asset maturity, asset volatility, and Merton's distance-to-default. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
market beta	0.353***	0.389***				
	(3.93)	(3.12)				
sys asset vol			2.723***			
			(2.96)			
id asset vol			-1.591			
			(-1.13)			
bank beta				0.311***		
				(2.64)		
tail beta					0.298**	
					(2.37)	
equity beta						0.035
						(0.38)
mkat		-0.179***	-0.195***	-0.179***	-0.170***	-0.178***
		(-4.08)	(-3.85)	(-4.00)	(-3.87)	(-4.01)
abnearn		0.258	0.274	0.331	0.347	0.363
		(0.71)	(0.80)	(0.91)	(0.95)	(0.94)
bklev		1.200***	0.920**	0.933**	1.092***	0.879**
		(3.29)	(1.98)	(2.25)	(2.93)	(2.03)
mk2bk		0.139***	0.175***	0.177***	0.149***	0.166***
		(2.95)	(2.98)	(4.19)	(3.09)	(3.93)
assetmat		0.004	0.007	0.001	0.005	0.003
		(0.28)	(0.54)	(0.06)	(0.35)	(0.20)
profitvol		-4.598*	-3.598*	-3.990	-3.639	-3.409
		(-1.72)	(-1.67)	(-1.50)	(-1.39)	(-1.43)
mertondd		-0.009	-0.025	-0.020	-0.021	-0.022**
		(-0.50)	(-1.29)	(-1.25)	(-1.40)	(-2.05)
Constant	-0.218**	0.983**	1.626*	1.130**	0.952**	1.269**
	(-2.41)	(2.04)	(1.73)	(2.35)	(2.02)	(2.37)
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,476	2,292	2,292	2,292	2,292	2,292
R^2	0.052	0.072	0.076	0.067	0.067	0.064

Table 11: **Debt Maturity: Systematic and Idiosyncratic Risk**

This table presents cross-sectional regressions of numerical debt maturity on firm-specific variables: beta, firm age, log market value, abnormal earning, book leverage, market-to-book ratio, asset maturity, profit volatility, and Merton's distance-to-default. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	Fama-MacBeth					Panel Regression				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
market beta	0.118	0.715***	0.857***		0.365***	0.202***	0.279***			
	(1.40)	(9.67)	(9.59)		(5.36)	(6.14)	(7.65)			
asset vol		-4.514***	-4.438***							
		(-18.58)	(-16.89)							
sys asset vol				2.694***				2.192***		
				(7.41)				(9.08)		
id asset vol				-4.496***				-0.543***		
				(-26.19)				(-3.55)		
bank beta									0.316***	
									(5.75)	
tail beta										0.258***
										(9.29)
mkat					0.419***		0.406***	0.395***	0.409***	0.397***
					(15.84)		(17.32)	(16.49)	(17.37)	(17.25)
abn earning					0.215**		0.178***	0.164***	0.189***	0.203***
					(2.39)		(3.93)	(3.58)	(4.24)	(4.48)
bklev			2.062***		2.194***		2.048***	1.991***	1.915***	1.921***
			(6.20)		(10.26)		(11.80)	(11.77)	(11.28)	(11.17)
mk2bk					-0.386***		-0.248***	-0.225***	-0.217***	-0.236***
					(-7.40)		(-4.64)	(-4.19)	(-4.09)	(-4.46)
asset mat					0.078***		0.058***	0.059***	0.059***	0.059***
					(17.44)		(6.95)	(7.11)	(6.96)	(6.90)
profit vol					-1.978***		-1.804***	-1.623***	-1.746***	-1.709***
					(-2.81)		(-4.13)	(-3.90)	(-4.06)	(-4.02)
mertondd					0.044***		0.036***	0.030***	0.031***	0.030***
					(4.17)		(4.10)	(3.28)	(3.33)	(3.28)
Constant	4.948***	6.076***	5.331***	6.144***	1.539***	5.032***	1.969***	2.125***	2.035***	2.126***
	(40.65)	(49.35)	(25.41)	(53.94)	(5.37)	(75.94)	(13.36)	(12.78)	(13.64)	(14.04)
Firm Controls	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes
Industry Fixed-Effect	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	51,223	51,223	50,663	51,223	44,250	51,223	44,250	44,250	44,250	44,100
R^2	0.006	0.072	0.092	0.073	0.213	0.026	0.165	0.166	0.164	0.164

Table 12: **Debt Maturity: Impact of Business Cycles**

This table presents regression results of the impact of macroeconomic variables on long-term debt share and debt maturity. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
rec	-0.317***	-0.367***	-0.326***	-0.377***	-0.405***	-0.476***	-0.288***	-0.340***	-0.280***	-0.331***
	(-5.25)	(-6.49)	(-5.77)	(-6.64)	(-5.02)	(-6.80)	(-5.87)	(-6.22)	(-6.60)	(-7.62)
market beta	0.226***	0.299***	0.573***	0.354***						
	(6.59)	(7.79)	(16.67)	(9.11)						
market beta × rec	0.140*	0.167**	0.181***	0.189***						
	(1.94)	(2.58)	(2.72)	(2.90)						
asset vol			-3.512***	-0.714***						
			(-25.63)	(-4.85)						
sys asset vol					2.639***	1.953***				
					(13.96)	(8.94)				
sys asset vol × rec					0.722*	0.908**				
					(1.86)	(2.24)				
id asset vol					-3.914***	-0.808***				
					(-27.22)	(-5.53)				
id asset vol × rec					0.456**	0.421**				
					(2.03)	(2.07)				
bank beta							0.374***	0.334***		
							(7.08)	(6.32)		
bank beta × rec							0.230**	0.263***		
							(2.49)	(2.69)		
tail beta									0.516***	0.277***
									(14.99)	(9.63)
tail beta × rec									0.122**	0.146**
									(2.09)	(2.47)
Quadratic Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	51,010	Yes
Observations	51,223	44,250	51,223	44,250	51,223	44,250	51,223	44,250	0.032	44,100
R^2	0.019	0.160	0.067	0.161	0.070	0.160	0.020	0.158	0.033	0.158

Table 13: **Sample Period 1974–2006**

This table presents regression results of the impact of macroeconomic variables on debt maturity excluding the financial crisis period (2007-2010). Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	long-term debt share			debt maturity		
	(1)	(2)	(3)	(4)	(5)	(6)
rec	-0.042***	-0.040***	-0.035***	-0.372***	-0.362***	-0.328***
	(-6.42)	(-5.61)	(-5.86)	(-6.59)	(-6.05)	(-6.93)
market beta	0.042***			0.327***		
	(8.89)			(7.71)		
market beta × rec	0.027***			0.214***		
	(4.08)			(3.68)		
bank beta		0.043***			0.370***	
		(7.10)			(6.82)	
bank beta × rec		0.041***			0.347***	
		(3.44)			(3.58)	
tail beta			0.035***			0.291***
			(9.46)			(9.32)
tail beta × rec			0.020***			0.182***
			(2.83)			(3.16)
Quadratic Trend	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	43,154	43,154	42,998	40,732	40,732	40,586
R^2	0.168	0.165	0.165	0.161	0.160	0.160

Table 14: **Different Measures of Long-Term Debt Share**

This table presents regression results of the impact of macroeconomic variables on debt maturity measured by ratios of long-term debt with maturity longer than 1 year, 2 years, 4 years and 5 years to total debt respectively. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	ldebt1y			ldebt2y		
rec	-0.033***	-0.029***	-0.031***	-0.034***	-0.024***	-0.034***
	(-5.54)	(-5.07)	(-5.92)	(-4.62)	(-4.09)	(-5.76)
market beta	0.034***			0.040***		
	(8.78)			(10.38)		
market beta × rec	0.022***			0.022**		
	(3.97)			(2.55)		
bank beta		0.038***			0.044***	
		(9.50)			(8.75)	
bank beta × rec		0.033***			0.022**	
		(3.76)			(2.07)	
tail beta			0.030***			0.035***
			(8.80)			(10.64)
tail beta × rec			0.024***			0.025***
			(3.71)			(3.41)
Quadratic Trend	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	53,991	53,991	53,797	47,554	47,554	47,389
R^2	0.101	0.099	0.099	0.150	0.147	0.148

	ldebt4y			ldebt5y		
rec	-0.039***	-0.039***	-0.034***	-0.041***	-0.038***	-0.036***
	(-5.92)	(-5.74)	(-6.21)	(-6.27)	(-6.06)	(-7.39)
market beta	0.034***			0.025***		
	(7.41)			(5.90)		
market beta × rec	0.014*			0.017**		
	(1.79)			(2.25)		
bank beta		0.034***			0.031***	
		(5.46)			(5.40)	
bank beta × rec		0.027**			0.027**	
		(2.21)			(2.37)	
tail beta			0.032***			0.024***
			(9.82)			(7.29)
tail beta × rec			0.007			0.013*
			(1.04)			(1.90)
Quadratic Trend	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	45,967	45,967	45,813	44,175	44,175	44,027
R^2	0.157	0.155	0.156	0.148	0.148	0.147

Table 15: **Firm Characteristics and Aggregate Trend**

This table presents regression results of the impact of macroeconomic variables on long-term debt share using the trend of the aggregate long-term debt share. Loadings on the aggregate trend depend on firm characteristics. Robust t-statistics are presented in parentheses. Significance at the 10%, 5%, and 1% levels is indicated by *, **, ***, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
rec	-0.036***	-0.034***	-0.034***	-0.032***	-0.037***	-0.039***
	(-5.50)	(-5.23)	(-5.66)	(-5.20)	(-6.56)	(-6.70)
asset beta	0.036***	0.035***				
	(7.89)	(7.48)				
asset beta × rec	0.018**	0.017**				
	(2.56)	(2.45)				
bank beta			0.037***	0.034***		
			(6.44)	(5.68)		
bank beta × rec			0.032***	0.028***		
			(2.98)	(2.65)		
tail beta					0.032***	0.031***
					(9.09)	(8.70)
tail beta × rec					0.023***	0.027***
					(3.15)	(3.64)
mkat	0.045***	0.206***	0.046***	0.208***	0.044***	0.214***
	(18.24)	(7.54)	(18.39)	(7.61)	(17.98)	(7.87)
mkat × trend		-0.250***		-0.251***		-0.264***
		(-5.97)		(-5.99)		(-6.32)
abnearn	0.018***	-0.298***	0.019***	-0.305***	0.020***	-0.282***
	(3.10)	(-2.84)	(3.43)	(-2.89)	(3.55)	(-2.62)
abnearn × trend		0.489***		0.503***		0.467***
		(3.03)		(3.09)		(2.83)
bklev	0.286***	2.471***	0.267***	2.433***	0.269***	2.494***
	(14.84)	(6.64)	(14.52)	(6.50)	(14.26)	(6.65)
bklev × trend		-3.404***		-3.374***		-3.465***
		(-5.94)		(-5.86)		(-6.00)
mk2bk	-0.035***	0.038	-0.031***	0.038	-0.034***	0.032
	(-5.74)	(0.60)	(-4.96)	(0.62)	(-5.48)	(0.50)
mk2bk × trend		-0.115		-0.109		-0.104
		(-1.18)		(-1.14)		(-1.05)
assetmat	0.007***	0.015	0.007***	0.014	0.007***	0.016
	(6.79)	(1.28)	(6.79)	(1.20)	(6.76)	(1.34)
assetmat × trend		-0.012		-0.010		-0.013
		(-0.65)		(-0.56)		(-0.71)
profitvol	-0.314***	1.850**	-0.306***	1.932**	-0.297***	2.026**
	(-6.68)	(2.12)	(-6.71)	(2.23)	(-6.54)	(2.34)
profitvol × trend		-3.353**		-3.470**		-3.603***
		(-2.46)		(-2.56)		(-2.66)
mertondd	0.006***	0.022*	0.006***	0.021*	0.006***	0.020*
	(6.29)	(1.89)	(5.39)	(1.77)	(5.37)	(1.73)
mertondd × trend		-0.024		-0.024		-0.023
		(-1.35)		(-1.29)		(-1.26)
trend	1.025***	3.991***	1.017***	3.969***	1.037***	4.094***
	(13.89)	(13.48)	(14.86)	(13.45)	(13.59)	(13.82)
Industry Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	46,978	46,978	46,978	46,978	46,818	46,818
R^2	0.164	0.170	0.162	0.168	0.162	0.169