

Net leverage, risk, and credit spreads [†]

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Abstract

This paper proposes a risk-based explanation of the negative relation between credit spreads and expected equity returns found in the data. In a model where issuing equity is costly and debt has a tax advantage, firms optimally choose a lower net leverage if their cash flows are more correlated to a source of aggregate fluctuations (i.e. if the firm is riskier), all else being equal. The model predicts that riskier firms have a lower net leverage and a lower credit spreads. I test these two predictions using data on U.S. public companies and I find that: (i) low net leverage firms earn a higher risk-adjusted return than high net leverage ones; (ii) risk-adjusted returns on net leverage sorted portfolios are negatively correlated to credit ratings (a proxy for credit spreads); and (iii) a net leverage-based factor has the potential to explain the variation in equity returns across portfolios sorted according to credit ratings.

Keywords: Expected equity returns, net leverage, credit spreads

JEL classification : G12, G32, D92

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1. Introduction

This paper explores the effects of a firm's cash flow riskiness on both its precautionary savings and its debt financing policies. When firms are allowed to borrow resources from a competitive lending sector, then those with cash flows more correlated to the aggregate economy (i.e., riskier firms) choose a lower net leverage because they face higher expected financing costs. On the other hand, less risky firms, having lower expected financing costs, optimally choose to issue more debt to exploit tax advantages. This behavior has the potential to replicate the negative correlation between credit spreads and equity returns observed in the data.

The model's setup is as follows. At time 0, a firm is endowed with a given level of net worth and it has to choose its optimal financing policy. The firm can raise external financing by issuing debt or equity. Equity issuance is assumed to be costly, while debt issuance implies a tax advantage. For these reasons, the firm prefers to repay its obligations by issuing debt first before issuing costly equity. The firm can also save cash, thus reducing future financing costs. Retaining cash is costly because the funds accumulated within the firm earn a lower return than shareholders could obtain outside of the firm. It follows that cash is negative debt because it is never optimal for the firm to raise external funds and save the proceeds. At time 1, the firm undertakes a profitable investment opportunity by paying a fixed investment cost. If the time 1 net worth is not enough to finance the entire investment, then the firm can raise costly external financing. At the same time, the firm can default if the time 1 value of the firm is negative. Default is costly because the shareholders' recovery value is zero, while the debt-holders can recover only a fraction of the time 1 cash flow.

In the model, riskier firms have a higher expected financing cost because they are more likely to experience a cash flows shortfall in those states in which they need external financing the most. This leads them to choose a lower net leverage at time 0. I illustrate this mechanism using a model that assumes an exogenous risk-free debt limit. Such a model is able to deliver the first testable implication of the model, namely a negative correlation between net leverage and equity returns. This result survives when I allow firms to issue risky debt. In this case, firms with a lower expected financing cost (less risky firms) are not restricted by the risk-free debt limit and choose to issue risky debt to exploit the tax advantage. Such a behavior delivers the second testable implication of the model, namely a negative correlation between credit spreads and equity returns.

To test the first prediction, I follow George and Hwang (2010) in constructing an investment strategy that discriminates between firms with high and low net leverage. I show that, on average,

low net leverage firms earn an excess return of 0.47% per month over firms with high net leverage, a result that supports the model predictions. When the same exercise is performed sorting firms on cash-to-asset or book leverage, the resulting excess returns are virtually the same as those generated when firms are sorted according to their net leverage. It follows that cash can be considered as negative debt for investment strategy purposes.

I also perform a portfolio analysis in the spirit of Fama and French (1992) by forming net leverage sorted portfolios. The data show that the Carhart (1997) four-factor model is not able to explain the variation in returns across the ten net leverage sorted portfolios. In this case, the difference in risk-adjusted returns between the top and bottom portfolios is negative and statistically significant. However, when I include a net leverage factor in the Carhart four-factor model, the differences in risk-adjusted returns are no longer significant. If I restrict the analysis to firms that have data on credit ratings (a proxy for credit spreads), the data support the model's prediction on a negative correlation between net leverage and (risk-adjusted) equity returns on one hand and credit ratings on the other.

I conclude the empirical analysis by showing that the net leverage based factor explains the cross-section of equity returns across credit rating sorted portfolios. When returns are adjusted with the Carhart four-factor model, the difference in risk-adjusted returns is negative and statistically significant for both equally weighted and value weighted portfolios, a result in line with other studies documenting an excess return of low credit risk firms over high credit risk ones (the so called *credit ratings puzzle*)¹. When the Carhart four-factor model is augmented with the net leverage based factor, the risk-adjusted return differential becomes smaller in absolute value and is not statistically different from zero.

My model belongs to a growing body of research that tries to explain how optimal financing and investment policies influence the cross-section of equity returns. Acharya, Davydenko, and Strebulaev (2011) build a model that generates a positive relation between cash holdings and credit spreads. In their setup, the debt level is predetermined and riskier firms are those closer to default, not those with cash flows more correlated with the aggregate economy. For this reason, Acharya, Davydenko, and Strebulaev (2011) do not draw any conclusions about the relation between equity returns and credit spreads. George and Hwang (2010) propose a model where the debt choice is

¹Studies that document the credit ratings puzzle include Dichev (1998), Griffin and Lemmon (2002), Avramov, Chordia, Jostova, and Philipov (2009), Garlappi and Yan (2011), Avramov, Chordia, Jostova, and Philipov (2012), and references therein.

endogenous and cash flows are risky—they model their correlation directly with an aggregate shock. They show that, in the presence of financial distress costs, equity returns and optimal leverage are negatively correlated. Unlike George and Hwang (2010), I do not assume heterogeneity in deadweight costs upon default across firms. In my setup, the presence of costly external financing is sufficient to generate a negative relation between leverage and expected equity returns. Differently from George and Hwang (2010), who focus exclusively on book-leverage, Gomes and Schmid (2010) and Ozdagli (2012) also study the relation between market leverage and equity returns. In both models, investment and financing choices are endogenous, but while in Ozdagli (2012) corporate debt is risk-free, in Gomes and Schmid (2010) firms can issue risky corporate debt.

Garlappi and Yan (2011) study how shareholder recovery upon default affects the relation between expected returns and expected default probabilities. They show that when shareholders do not recover anything, the relation between expected returns and expected default probabilities is positive, while when shareholders are able to recover a fraction of the firm’s value upon default, expected returns and expected default probabilities show an inverse U-shaped relation. Despite assuming a zero recovery upon default for the equity holders, my model is still able to generate a negative relation between expected returns and expected default probabilities.

Glover (2011) proposes the model most closely related to the one developed in this paper. He builds a dynamic capital structure model in the tradition of Merton (1974) and Leland (1994) to structurally estimate the expected cost of default. In his framework, firms differ in their cost of default and those with a higher expected cost have a lower leverage and a lower default probability. It follows that using the subset of defaulted firms to estimate the expected cost of default leads to a negative bias. Unlike this paper, Glover (2011) does not explicitly explore the link between optimal leverage policies, expected equity returns, and credit spreads².

The relation between corporate financing policies and equity returns has been extensively studied in the field of empirical asset pricing. Bhandari (1988) performs one of the first studies that connects corporate financing policies to the cross-section of equity returns. He uses market leverage in cross-sectional regressions in the spirit of Fama and MacBeth (1973) as a proxy for the underlying risk of common equity and he finds that this variable carries a positive risk premium. Fama and French (1992) perform similar cross-sectional regressions, decomposing the log of the book-to-market ratio

²More recently, Bhamra, Kuehn, and Strebulaev (2010) and Kuehn and Schmid (2012) extend a structural model of credit risk to a consumption-based asset pricing model with endogenous leverage and investment decisions. Unlike this paper, their main goal is to assess the impact of endogenous corporate decisions on the term structure of credit spreads and their time-series (i.e., business-cycle) properties.

in the difference between the log market leverage and the log book leverage. They show that what really matters is the difference between the two variables (i.e., the book-to-market ratio) because the risk premia on the two leverage ratios have opposite signs and very similar absolute value.

Penman, Richardson, and Tuna (2007) perform the empirical analysis most closely related to the one in this paper. They show that two-dimensional portfolio sortings on book-to-market and financial leverage, measured as the ratio of net leverage over the the market value of common equity, uncover “*a seemingly perverse finding*”, namely a significant (size-adjusted) excess return of low-financial-leverage firms over high-financial-leverage firms. Furthermore, a standard linear factor model is not able to explain the documented differences in returns. Unlike their study, I propose a model that has to potential to rationalize the observed negative relation between net leverage and equity returns.

Other studies, complementary to those focusing on leverage, have explored the role of corporate savings policies in shaping the cross-section of equity returns. In particular, both Simutin (2010) and Palazzo (2012) find that high cash holdings are positively related with expected equity returns and that commonly used linear factor models cannot explain the variation in returns across cash-sorted portfolios³. By showing that cash can be considered as negative debt for investment strategy purposes, this study also provides an attempt to unify previous studies that have so far separately considered the role of leverage and cash holdings as explanatory variables for the cross-section of equity returns.

In what follows, I describe a three-period model and its implications for the relation between net leverage and equity returns in Section 2. In Section 3, I test the model’s implications using standard empirical asset pricing techniques. Section 4 concludes.

2. Model

This section presents a model that extends the one in Palazzo (2012) to allow for debt financing in the first stage. I first show that when only risk-free debt is allowed, optimal net leverage is negatively related to firms’ risk, as measured by the correlation of cash flows with an aggregate source of economic fluctuations. Then, I allow the firms to issue risky corporate debt. In such a scenario, the negative relation between optimal net leverage and firms’ risk survives. In addition,

³Penman, Richardson, and Tuna (2007) also document a positive risk premium for corporate cash holdings, measured as the ratio of cash and short-term investments over the market value of common equity.

I show that less risky firms have lower expected returns, higher net leverage, and higher credit spreads.

2.1. Set-up

Consider a three-period model, with periods indexed by $t = 0, 1, 2$. At time $t = 0$, a firm is endowed with a given level of net worth W_0 and an asset that produces a random cash flow in period 1 only. At time 1, after the realization of the asset's cash flow, the firm receives an investment opportunity with probability π , $\pi \in [0, 1]$. This opportunity consists of the option of installing an asset that produces a deterministic cash flow, C_2 , at time 2. The latter cash flow is not pledgeable at time $t = 1$. To simplify the problem, I assume that the time 1 present discounted value of the project's cash flow, $\frac{C_2}{R}$, is greater than the investment cost when the latter is entirely equity financed, $1 + \lambda$. This condition is sufficient to ensure that the firm always invests at time 1 if there is an investment opportunity and the time 1 net worth is non-negative.

If the firm installs the asset at time $t = 1$, then it pays a sunk investment cost equal to 1. If internal cannot cover the investment cost and repay time 1 liabilities, then the firm can issue equity. Equity financing involves a proportional issuance cost equal to λ . The firm can also transfer cash from one period to the next and I assume an accumulation rate $\hat{R}$ smaller than the risk-free rate R to prevent an unbounded accumulation of cash internally to the firm.

The firm can issue corporate debt at time 0, thus reducing the amount of equity issuance when the initial net worth is negative. The firm prefers to issue debt instead of equity because there is a tax advantage: interests paid on corporate debt are tax deductible. Since I am interested in the optimal financing choice at time $t = 0$, I simplify the setup by not allowing for debt financing at time $t = 1$. A more realistic setting with costly debt restructuring at time 1 will only complicate the analysis without changing the key predictions of the model.

2.2. The firm's problem

At time 0, the firm decides whether to default or continue with its operations. Conditional on not defaulting, the firm decides how much cash to borrow (B_1), how much cash to retain as savings (S_1), and how much cash to distribute as dividends (D_0). If net worth is positive at the beginning of time 0, the maximum amount of resources that the firm can save is W_0 . It follows that S_1 is always in the interval $[0, \hat{R}W_0]$.

Conditional on investing at time 1, the firm issues equity only if corporate savings, S_1 , plus the cash flow generated by the asset in place are not enough to finance the cost of investment and to repay debt. In this case, the dividend at time 1 (D_1) is negative and the firm pays λD_1 in issuance costs. The last period dividend is the cash flow produced by the safe asset, $D_2 = C_2$. If the firm does not invest at time 1, the internal resources are used to repay debt and to distribute dividends to shareholders. In this case, the time 2 dividend is equal to zero. Before writing down the firm's optimization problem, I briefly discuss the time 0 and time 1 budget constraints and the bond pricing equation that I use to pin down the time 1 debt repayment.

2.2.1. Time 0 and time 1 budget constraints

At time 0, the firm's budget constraint is

$$D_0 = W_0 + B_1 - \frac{S_1}{R}. \quad (1)$$

The firm can use the total resources available to distribute dividends (D_0) or to accumulate cash internally $\left(\frac{S_1}{R}\right)$. If the initial net worth W_0 is negative, then the firm raises external financing to repay pre-existing liabilities. Given that there is a tax advantage of debt, the firm will first issue debt B_1 and then use the more expensive equity. If D_0 is negative (i.e. the firm has exhausted its debt capacity and uses equity to finance the initial time 0 liabilities), the equity issuance cost is λD_0 . In what follows, $\mathbf{1}_{[D_0 \leq 0]}$ is an indicator function that takes value 1 only if the firm needs to issue equity to finance its operations at time 0.

To derive the time 1 budget constraint, I first write down the firm's net worth at time 1:

$$W_1 = S_1 + (1 - \tau)e^{x_1} - \left(\widehat{B}_1 - \tau(\widehat{B}_1 - B_1)\right) = S_1 + (1 - \tau)e^{x_1} - L_1. \quad (2)$$

Interest paid on corporate debt is tax deductible, so the net repayment is equal to the promised repayment, $\widehat{B}_1$, net of the reduction in corporate taxes, $\tau(\widehat{B}_1 - B_1)$. If the realized earnings are negative, the firm does not pay corporate taxes but still benefits from the tax advantage of debt. To simplify the notation, I introduce a new variable, L_1 , that is equal to repayment to the bondholders net of the tax deduction.

The term e^{x_1} is the cash flow generated by the asset in place. This cash flow is risky because it is correlated with the pricing kernel that the firm uses to discount future cash flows. The pricing

kernel is modeled following Berk et al. (1999) and Zhang (2005)⁴.

The value of the firm at time 1 equals

$$V_1^{invest} = \max \left\{ 0, (1 + \lambda \mathbf{1}_{[D_1 \leq 0]}) D_1 + \frac{C_2}{R} \right\}, \quad (3)$$

where $D_1 = W_1 - 1$ and $\mathbf{1}_{[D_1 \leq 0]}$ is an indicator function that takes value 1 if the internal resources at time 1, $(1 - \tau)e^{x_1} + S_1$, are not enough to finance the fixed cost of investment and the debt repayment, $L_1 + 1$. This corresponds to the case in which the net worth W_1 is less than the fixed cost of investment. This event crucially depends on the realization of the random variable x_1 . In particular, if x_1 is lower than the threshold $\kappa_i = \log \left(\frac{L_1 + 1 - S_1}{1 - \tau} \right)$, then equity issuance becomes necessary.

The firm defaults if the value to invest at time 1 is negative, namely when the net worth W_1 is less than $W_{di} = 1 - \frac{C_2}{(1 + \lambda)R} < 1$. This happens when the random variable x_1 is lower than the threshold $\kappa_{di} = \log \left(\frac{L_1 + 1 - S_1 - (1 + \lambda)^{-1} C_2 / R}{1 - \tau} \right)$. Given that $\kappa_i > \kappa_{di}$, then no equity issuance implies no default.

Conditional on not receiving an investment opportunity, the firm has to repay the debt to the bondholders and distribute the residual cash to the shareholders as dividends. The value of the firm is equal to

$$V_1^{noinvest} = \max\{0, D_1\}, \quad (4)$$

and the firm will default whenever $D_1 = W_1 < 0$, namely when x_1 is below the threshold $\kappa_{dn} = \log \left(\frac{L_1 - S_1}{1 - \tau} \right)$. Notice that κ_{dn} is smaller than κ_i and, at the same time, κ_{dn} is bigger than κ_{di} . The last result follows directly from the assumption that $\frac{C_2}{R}$ is greater than $1 + \lambda$.

⁴The cash flow produced at time $t = 1$ is discounted using the factor

$$M_1 = e^{m_1} = e^{-r - \frac{1}{2}\sigma_z^2 - \sigma_z \varepsilon_{z,1}},$$

where $\varepsilon_{z,1} \sim N(0, 1)$ is the aggregate shock at time $t = 1$. The above formulation implies $E_0[M_1] = e^{-r} = 1/R$. The pay-off produced by the risky asset at time 1 is e^{x_1} , where x_1 is equal to

$$x_1 = \mu - \frac{1}{2}\sigma_x^2 + \sigma_x \varepsilon_{x,1}.$$

The cash flow shock, $\varepsilon_{x,1} \sim N(0, 1)$, is correlated with $\varepsilon_{z,1}$, thus making the cash flows produced by the asset in place risky. In what follows, I assume that $COV(\varepsilon_{z,1}, \varepsilon_{x,1}) = \sigma_{x,z}$ and, as a consequence, $COV(x_1, m_1) = -\sigma_x \sigma_z \sigma_{x,z}$. As in Berk, Green, and Naik (1999), the systematic risk of a project's cash flow, β_{xm} , is equal to $\sigma_x \sigma_z \sigma_{x,z}$.

2.2.2. Fair Pricing Equation

In this model, corporate debt is risky because the firm has the option to default at time 1. The lending industry is perfectly competitive and free entry is assumed so that lenders get no surplus from the lending activity. If the firm defaults, then the lender only recovers a fraction ξ of the liquid assets of the firm at time 1, $(1 - \tau)e^{x_1} + S_1$. The above assumptions imply the following bond pricing equation:

$$B_1 = E_0 \left[M_1 \left(\hat{B}_1 \mathbf{1}_{[V_1 > 0]} + \xi ((1 - \tau)e^{x_1} + S_1) (1 - \mathbf{1}_{[V_1 > 0]}) \right) \right], \quad (5)$$

where $\mathbf{1}_{[V_1 > 0]}$ is an indicator variable that takes a value of 1 if the firm decides not to default at time 1. Using the fact that the variables B_1 and L_1 are known at time 0 and that $\hat{B}_1$ can be rewritten as $\frac{L_1}{1 - \tau} - \frac{\tau B_1}{1 - \tau}$, the bond pricing equation becomes

$$B_1 = \frac{L_1}{\left(\tau + (1 - \tau) (E_0 [M_1 \mathbf{1}_{[V_1 > 0]})]^{-1} \right)} + \frac{\xi E_0 [M_1 ((1 - \tau)e^{x_1} + S_1) (1 - \mathbf{1}_{[V_1 > 0]})]}{\left(1 + \frac{\tau E_0 [M_1 \mathbf{1}_{[V_1 > 0]})}{(1 - \tau)} \right)}. \quad (6)$$

If the probability of default at time 1 is zero ($\mathbf{1}_{[V_1 > 0]} = 1$), then the gross corporate interest rate equals $R - \tau(R - 1)$ ⁵.

2.2.3. Optimization Problem

The time 0 value of the firm is

$$V(W_0) \equiv \max \left\{ 0, \max_{S_1 \geq 0, B_1 \geq 0} (1 + \lambda \mathbf{1}_{[D_0 \leq 0]}) D_0 + E_0 [M_1 V_1] \right\}, \quad (7)$$

where

$$B_1 = \frac{L_1}{\left(\tau + (1 - \tau) (E_0 [M_1 I_{V_1 > 0}])^{-1} \right)} + \frac{\xi E_0 [M_1 ((1 - \tau)e^{x_1} + S_1) (1 - I_{V_1 > 0})]}{\left(1 + \frac{\tau (E_0 [M_1 I_{V_1 > 0}])}{(1 - \tau)} \right)} \quad (8)$$

$$D_0 = W_0 + B_1 - \frac{S_1}{\widehat{R}}, \quad (9)$$

⁵For a similar derivation see, among others, Li (2009) and Gomes and Schmid (2010).

$$V_1 = \begin{cases} V^{invest} & \text{with probability } \pi \\ V^{noinvest} & \text{with probability } 1-\pi \end{cases}. \quad (10)$$

In what follows, I make two assumptions for the sake of analytical tractability. First, I assume that the probability of investing next period is always equal to one ($\pi = 1$). Second, I assume that the lender cannot recover any fraction of the liquid assets of the firm at time 1 ($\xi=0$).

2.3. Risk-free corporate debt

In this subsection, I use the risk-free debt case to show how a negative relation between risk and net leverage emerges in the presence of costly equity issuance and tax advantage of debt. In particular, I assume that the net worth at time 1, W_1 , cannot be lower than $1 - \frac{C_2}{(1+\lambda)R}$ for each possible realization of the time 1 cash flow; namely, the firm can borrow up to $\overline{L}_1 = \frac{C_2}{(1+\lambda)R} - 1$. The restriction $L_1 \leq \overline{L}_1$ implies a corporate interest rate equal to the internal accumulation rate $\hat{R} = e^r - \tau(e^r - 1) < e^r = R$, where R is a constant gross risk-free interest rate.

Under the above assumptions, the firm's period 0 and period 1 budget constraints become

$$D_0 = (1 + \lambda \mathbf{1}_{[D_0 \leq 0]}) \left(W_0 + \frac{N_1}{\hat{R}} \right), \quad (11)$$

and

$$D_1 = (1 + \lambda \mathbf{1}_{[D_1 \leq 0]}) ((1 - \tau)e^{x_1} - N_1 - 1) = (1 + \lambda \mathbf{1}_{[D_1 \leq 0]}) (W_1 - 1), \quad (12)$$

where $N_1 = L_1 - S_1$ is the amount of risk-free debt net of cash. Notice that N_1 can be interpreted as the firm's net leverage at the end of the first period. The time 0 value of the firm is

$$V(W_0) \equiv \max \left\{ 0, \max_{N_1 \leq \overline{L}_1} (1 + \lambda \mathbf{1}_{[D_0 \leq 0]}) \left(W_0 + \frac{N_1}{\hat{R}} \right) + [(1 - \tau)e^{\mu - \beta_{xm}} (1 + \lambda \Phi_3) - (N_1 + 1) (1 + \lambda \Phi_4) + C_2/R] / R \right\}, \quad (13)$$

where $\varepsilon_i = \frac{\kappa_i - \mu + 0.5\sigma_x^2}{\sigma_x}$, $\Phi_3 = \Phi\left(\varepsilon_i + \frac{\beta_{xm}}{\sigma_x} - \sigma_x\right)$, $\Phi_4 = \Phi\left(\varepsilon_i + \frac{\beta_{xm}}{\sigma_x}\right)$, and $\Phi(\cdot)$ is the cumulative distribution of a standard normal variable⁶.

If the time 0 net worth is negative and in absolute value larger than $\overline{L}_1$, then the optimal value

⁶See Appendix A.1. for the derivation.

of N_1 is exactly $\overline{L}_1$. On the other hand, if the time 0 net worth is positive but smaller than the unconstrained optimal choice of savings, then the optimal value of N_1 is $-W_0$. In the remaining cases the optimal choice of N_1 is determined by the Euler equation below:

$$\frac{(1 + \lambda \mathbf{1}_{[D_0 \leq 0]})}{\widehat{R}} = \frac{(1 + \lambda \Phi_4)}{R}. \quad (14)$$

If the firm's value of W_0 is positive, then the Euler reduces to

$$\frac{1}{\widehat{R}} = \frac{(1 + \lambda \Phi_4)}{R}. \quad (15)$$

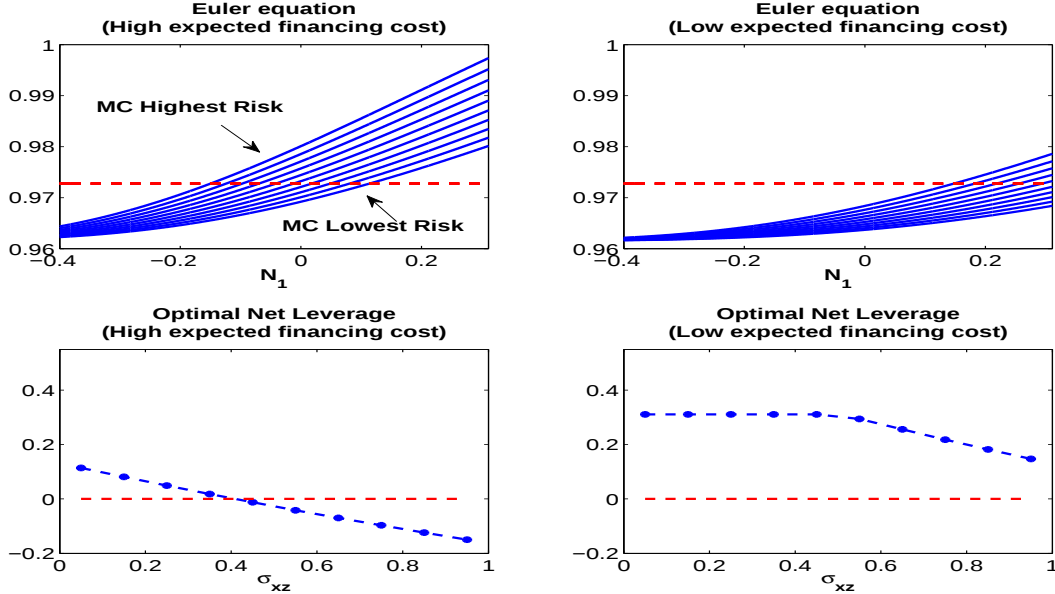
Without equity issuance costs ($\lambda = 0$), the left-hand side is larger than the right-hand side ($\widehat{R} < R$) and it would be optimal for a firm to issue debt up to the debt limit in order to maximize the tax advantage of debt. However, with equity issuance costs ($\lambda > 0$), the larger the debt issued at time 0 the larger the expected financing costs at time 1. In this case, less risky firms, having a lower probability of being financially constrained at time 1, issue debt up to $\overline{L}_1$ to increase the time 0 dividend payment, while riskier firms, having a higher probability of being financially constrained at time 1, save to reduce their expected financing cost⁷. Figure 1 depicts the marginal benefit (constant dotted red line) and the marginal cost of net leverage (increasing solid blue line) for different levels of riskiness and expected cash flows. The left panels report the optimal policies for firms with low expected cash flows (i.e. high probability of being financially constrained), while the right panels report the optimal policies for firms with high expected cash flows (i.e. low probability of being financially constrained). In the former case, optimal net leverage monotonically decreases with cash flow riskiness: low-risk firms borrow to finance current dividend distributions, while high-risk firms save to reduce expected financing costs. In the latter case, low-risk firms hit their risk-free debt limit, while high-risk firms optimally choose a lower leverage given their higher expected financing cost.

If W_0 is negative, then it is optimal to repay all of the liabilities issuing debt up to the debt limit. If all the liabilities have been paid and the debt limit has not been reached ($|W_0| \leq \overline{L}_1$), the firm can decide to issue an additional amount of debt, $\tilde{N}_1 > 0$, to maximize the tax advantage. In such a case, the Euler equation becomes

$$\frac{1}{\widehat{R}} = \frac{(1 + \lambda \tilde{\Phi}_4)}{R}, \quad (16)$$

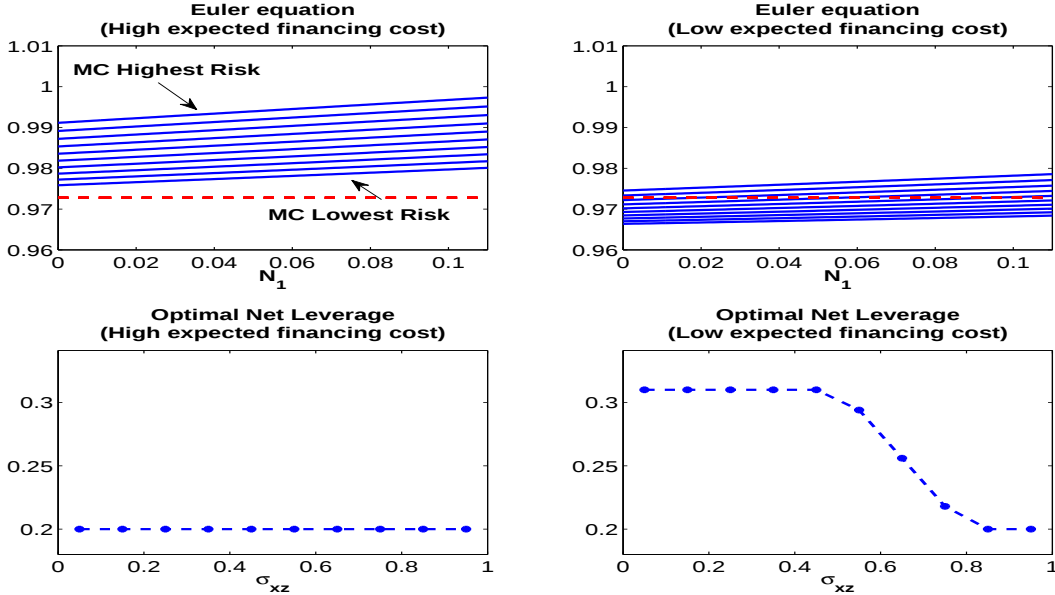
⁷ Note that if it is optimal to distribute a positive dividend at time 0, then a Modigliani–Miller irrelevance result applies between cash and debt. The optimal N_1 is negative and its value is given by any combination of L_1 and S_1 that satisfies (1) $N_1 = L_1 - S_1$, (2) $S_1 \in [\widehat{R}(W_0 - D_0), \widehat{R}W_0]$, (3) $L_1 \in [0, \overline{L}_1]$, and (4) $W_0 + \frac{N_1}{\widehat{R}} = D_0 > 0$. Also notice that if the unconstrained optimal value of savings is larger than W_0 , then it is not optimal for the firm to issue debt and save the proceeds. In the latter case, the optimal level of cash holdings is $S_1 = -N_1 = \widehat{R}W_0$.

Figure 1: Optimal financing policy when $W_0 > 0$



The top panels depict the marginal cost (solid blue line) and the marginal benefit (dashed red line) of net leverage for the case in which time 0 net worth is positive for different values of the firm's riskiness. The bottom panels depict the optimal net leverage policy as a function of the cash flows correlation with the aggregate shock (dotted blue line). The left panels present the case with high expected financing cost (i.e. low expected cash flows). The right panels present the case with low expected financing cost (i.e. high expected cash flows). The parameter values are $W_0 = 1$, $R = 1.04$, $\tau = 0.30$, $\lambda = 0.10$, $\sigma_x = 0.5$, $\sigma_z = 0.4$, and $C_2 = 1.5$ in both cases, while μ equals 1.2 in the high expected financing cost case and 1.5 in the low expected financing cost case.

Figure 2: Optimal financing policy when $-\bar{L}_1 < W_0 < 0$



The top panels depict the marginal cost (solid blue line) and the marginal benefit (dashed red line) of net leverage for the case in which time 0 net worth is negative, but smaller than the debt limit in absolute value, for different values of the firm's riskiness. The bottom panels depict the optimal net leverage policy as a function of the cash flows' correlation with the aggregate shock (dotted blue line). The left panels present the case with high expected financing cost (i.e. low expected cash flows). The right panels present the case with low expected financing cost (i.e. high expected cash flows). The parameter values are $W_0 = -0.2$, $R = 1.04$, $\tau = 0.30$, $\lambda = 0.10$, $\sigma_x = 0.5$, $\sigma_z = 0.4$, and $C_2 = 1.5$ in both cases, while μ equals 1.2 in the high expected financing cost case and 1.5 in the low expected financing cost case.

where

$$\tilde{\Phi}_4 = \Phi \left(\frac{\log \left(\frac{\min\{|W_0| + \bar{N}_1, \bar{L}_1\} + 1}{1 - \tau} \right) - \mu + 0.5\sigma_x^2}{\sigma_x} + \frac{\beta_{xm}}{\sigma_x} \right). \quad (17)$$

Figure 2 depicts the marginal benefit (constant dotted red line) and the marginal cost of net leverage (increasing solid blue line) for different levels of riskiness and different expected cash flows when $W_0 < 0$. As in Figure 1, the left panels report the optimal policies for firms with low expected cash flows (i.e. high probability of being financially constrained), while the right panels report the optimal policies for firms with high expected cash flows (i.e. low probability of being financially constrained). As we can see, when the probability of being financially constrained is high, the marginal cost of issuing debt in excess of the time 0 net worth is always larger than the marginal benefit and all the firms prefer not to issue debt in addition to the amount required to pay off the time 0 liabilities (left panels). On the other hand, when the probability of being financially constrained is low, less risky firms prefer to issue additional debt to exploit the tax advantage (right panels).

Result 1 below formalizes the intuition provided in Figures 1 and 2. The derivation can be found in Appendix A.2.

Result 1. *When an interior solution to the risk-free corporate debt problem exists, the amount of optimal net leverage is decreasing in the firm's riskiness.*

2.4. Risky corporate debt

In this subsection, I relax the risk-free debt assumption and allow the firms to fully exploit the tax advantage. Corporate debt becomes risky whenever there is a state such that $V_1^{invest} < 0$. In this case, I use the fair pricing formula in Equation (8) to derive the value of debt that a firm can raise today for a given promised repayment tomorrow. Remember that a firm issues debt for two main reasons: (i) to pay time 0 liabilities, thus avoiding costly equity issuance Second, and (ii) to take advantage of the tax shield by distributing time 0 dividends using the debt proceeds. Note that it is never optimal for the firm to issue debt and save the proceeds because the internal accumulation rate is lower than the risk-free rate (i.e., cash is negative debt). For this reason, we

can use net leverage as the unique choice variable. The bond pricing equation for $N_1 > 0$ is

$$B_1 = E_0 \left[M_1 \left(\hat{B}_1 I_{V_1 > 0} \right) \right] = \frac{N_1}{\left(\tau + (1 - \tau) (E_0 [M_1 I_{V_1 > 0}])^{-1} \right)} = N_1 \left(\tau + (1 - \tau) R (1 - \Phi_2)^{-1} \right)^{-1}, \quad (18)$$

where $\varepsilon_{di} = \frac{\kappa_{di} - \mu + 0.5\sigma_x^2}{\sigma_x}$ and $\Phi_2 = \Phi \left(\varepsilon_{di} + \frac{\beta_{xm}}{\sigma_x} \right)$. Note that for combinations of cash and debt that generate a net leverage N_1 less or equal to $\overline{L}_1$, corporate debt is risk-free. If the time 1 net leverage is larger than $\overline{L}_1$, then corporate debt becomes risky and requires a rate larger than $\hat{R}$. In particular, the gross interest rate is equal to $N_1/B_1 = \tau + (1 - \tau) R (1 - \Phi_2)^{-1}$. It follows that the credit spread, defined as the difference between the corporate rate and $\hat{R}$, is

$$s_1(N_1) = \frac{N_1}{B_1} - \hat{R} = (1 - \tau) R \left(\frac{\Phi_2}{1 - \Phi_2} \right), \quad (19)$$

and we can rewrite B_1 as

$$B_1 = N_1 \left(\hat{R} + s_1(N_1) \right)^{-1}. \quad (20)$$

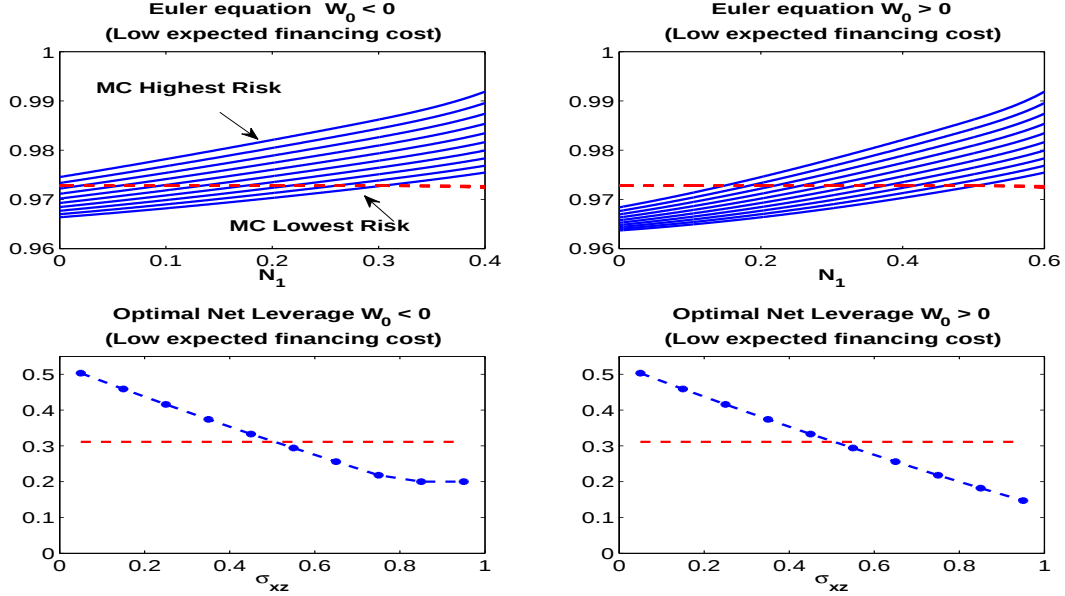
Appendix A.3. shows that B_1 has a unique maximum at N_1^{max} on $[0, +\infty]$ and it is strictly increasing on $[0, N_1^{max}]$. N_1^{max} is the firm's endogenous debt limit and it depends on the model's parameters. In addition, the credit spread is increasing in N_1 , increasing in the firm's riskiness, and decreasing in the firm's expected cash flows, all else being equal.

As in the risk-free case, the optimal net leverage choice crucially depends on the time 0 firm's net worth. If W_0 is positive, then a firm can save cash if it has high expected financing costs or it can issue debt to distribute a dividend larger than W_0 at time 0. In both cases the Euler equation is

$$\left(1 - \mathbf{1}_{[N_1 \geq \overline{L}_1]} \right) \frac{1}{\hat{R}} + \mathbf{1}_{[N_1 \geq \overline{L}_1]} \frac{dB_1}{dN_1} = \frac{\left[1 + \lambda \Phi_4 + \mathbf{1}_{[N_1 \geq \overline{L}_1]} \left(\frac{\Phi_2' e^{-r} C_2}{\sigma_x (N_1 + 1 - (1 + \lambda)^{-1} C_2 / R)} - (1 + \lambda) \Phi_2 \right) \right]}{R}, \quad (21)$$

where $\mathbf{1}_{[N_1 \geq \overline{L}_1]}$ is an indicator variable that takes a value of 1 if net leverage is larger than the risk-free debt limit and a value of zero otherwise. When the indicator variable is zero, the Euler equation is the same as that for the risk-free case. On the other hand, when the indicator variable equals one, the marginal benefit of debt is the derivative of B_1 with respect to N_1 , while the marginal cost has an additional component equal to $\frac{\Phi_2' e^{-r} C_2}{\sigma_x (N_1 + 1 - (1 + \lambda)^{-1} C_2 / R)} - (1 + \lambda) \Phi_2$. This additional term is the marginal cost represented by the forgone investment opportunity at time 1 net of the marginal benefit implied by the default option.

Figure 3: Optimal financing policy with risky debt



The top panels depict the marginal cost (solid blue line) and the marginal benefit (dashed red line) of net leverage for the case in which the time 0 net worth is negative (left top panel) and positive (right top panel) for different values of the firm's riskiness. The bottom panels depict the implied optimal net leverage policy as a function of the cash flows' correlation with the aggregate shock (dotted blue line). The dotted red line in the bottom panels is the risk-free debt limit. The parameter values are $\mu = 1.2$, $R = 1.04$, $\tau = 0.30$, $\lambda = 0.10$, $\sigma_x = 0.5$, $\sigma_z = 0.4$, and $C_2 = 1.5$ in both cases, while W_0 equals -0.2 in the negative net worth case and 1.0 in the positive net worth case.

When W_0 is negative, N_1 is always positive because it is not optimal for the firm to save. In this case the marginal benefit of debt (the LHS of Equation (21)) needs to be multiplied by $(1 - \lambda \mathbf{1}_{[D_0 \leq 0]})$ to capture the presence of equity issuance costs. As in the risk-free case, it is always optimal to finance the time 0 liabilities using debt for any value of W_0 smaller in absolute value than $\overline{L}_1$.

Figure 3 illustrates what happens when I remove the debt limit. I report the case of low expected financing costs for both negative and positive values of the time 0 net worth. Unlike from what is reported in the right panels of Table 1 and Table 2, less risky firms are not constrained by a risk-free debt limit (the dotted red line in the bottom panels of Figure 3) and optimally decide to increase their net leverage by issuing additional risky debt.

Appendix A.4. shows that an increase in the firm's riskiness causes a decrease in optimal net leverage, so the model predicts that riskier firms should optimally choose a lower net leverage. Result 2 formalizes the intuition provided in Figure 3 and extends the result of the previous section to a setting with risky debt.

Result 2. *When an interior solution to the risky corporate debt problem exists and N_1 approaches*

$\overline{L}_1$, the amount of optimal net leverage is decreasing in the firm's riskiness.

2.4.1. Net leverage, credit spreads, and expected equity returns

The ex-dividend value of the firm at time 0 is

$$E_0[M_1 V_1] = e^{-r} \left[(1 - \tau) e^{\mu - \beta_{xm}} \left(1 + \lambda \Phi_3 - (1 + \lambda) \Phi_1 \right) - (N_1 + 1) \left(1 + \lambda \Phi_4 - (1 + \lambda) \Phi_2 \right) + e^{-r} C_2 (1 - \Phi_2) \right],$$

and the expected return between time 0 and time 1 is equal to the ratio of the time 0 expected future dividends over the time 0 ex-dividend value of equity, as described in Equation (22):

$$E_0[R_{0,1}] = \frac{E_0[D_1 + P_1]}{P_0} = \frac{E_0[(1 + \lambda \mathbf{1}_{[D_1 \leq 0]}) (W_1 - 1) + e^{-r} C_2]}{E_0[M_1 V_1]}. \quad (22)$$

The equation above depends on the cash flow riskiness σ_{xz} , so that it takes the form of $f(\sigma_{xz})/g(\sigma_{xz})$. In Appendix A.5., I show that if the derivative of the expected future dividends ($f(\sigma_{xz})$) w.r.t. σ_{xz} is positive, then a sufficient condition that guarantees expected returns increasing in σ_{xz} is to require a continuation value $g(\sigma_{xz}) = E_0[M_1 V_1]$ decreasing in σ_{xz} . It follows that the model predicts a negative relation between expected equity returns and the optimal net leverage of the firm.

Result 3. *Under the assumption of a continuation value decreasing in the firm's riskiness, expected equity returns and optimal net leverage are negatively related.*

The effect of an increase in riskiness on a firm's credit spread is given by

$$\frac{ds_1(N_1)}{d\sigma_{xz}} = (1 - \tau)(1 - \Phi_2)^{-2} \Phi_2' \left(\sigma_z + \frac{1}{\sigma_x(N_1 - \overline{L}_1)} \frac{dN_1}{d\sigma_{xz}} \right). \quad (23)$$

The sign of the above derivative depends on the sign of $\left(\sigma_z + \frac{1}{\sigma_x(N_1 - \overline{L}_1)} \frac{dN_1}{d\sigma_{xz}} \right)$. Given that $\frac{dN_1}{d\sigma_{xz}}$ is negative, credit spreads are decreasing in the firm's cash flow riskiness when

$$\left| \frac{dN_1}{d\sigma_{xz}} \right| > \sigma_z \sigma_x (N_1 - \overline{L}_1). \quad (24)$$

The condition in Equation (24) holds for a wide set of plausible parameter values and allows the model to generate a negative relation between firms' credit spreads and expected equity returns. The intuition goes as follows. Firms with high cash flow riskiness are more likely to be financially constrained in the future, so they borrow less to reduce the expected financing cost. On the other

hand, firms with low cash flow riskiness have a lower probability of issuing equity to finance the time 1 investment, all else being equal, so they decide to borrow more and above the risk-free debt limit to take advantage of the tax shield.

Result 4. *When the condition in Equation (24) holds, expected equity returns and credit spreads are negatively related.*

3. Empirical analysis

In the first part of the empirical analysis, I document a negative relation between net leverage and equity returns. In particular, I follow George and Hwang (2010) and I show that an investment strategy that discriminates between the stocks of firms in the bottom 20% of the net leverage distribution and the stocks of firms in the top 20% earns a positive excess return. This excess return is similar to the excess return generated by (i) an investment strategy that discriminates between the stocks of firms sorted according to their book leverage and (ii) an investment strategy that discriminates between the stocks of firms sorted according to their cash-to-asset ratio. It follows that cash can be considered as negative debt for investment strategy purposes.

I also perform a portfolio analysis that sorts firms into net leverage deciles. The data show that the standard factors used in empirical asset pricing to risk-adjust equity returns are not able to explain the variation in returns across these portfolios. Further, when I also add a net leverage based factor, the difference in risk-adjusted returns between the bottom and top portfolios is no more significant.

Then, I restrict the analysis to firms that have data on credit ratings, a proxy for credit spreads. I do this to test the hypothesis that equity returns and firm credit spreads are also negatively related. To conclude, I show that the net leverage based factor also has the potential to explain the cross-section of equity returns across credit rating sorted portfolios.

3.1. Data

Accounting data are from Compustat, while prices and returns data are from the Center for Research in Security Prices (CRSP). I consider only ordinary common shares (share codes 11 and 12) and I exclude observations related to shares that are suspended, halted or not listed on the New York Stock Exchange (NYSE), the Nasdaq Stock Market (NASDAQ), or the American Stock Exchange

(AMEX) (exchange codes 1, 2, and 3). If a stock undergoes a performance delist after portfolio formation and the delisting return is missing, I follow Shumway (1997) and assign to the missing equity returns a value of -30%.⁸ If a stock delisting is not due to poor performance then I assume a -100% delisting return. A stock's market value of equity in month t ($Size$) is equal to the value of the firm's market capitalization in month t . The monthly risk-free interest rate and the observations for the Fama and French and momentum factors are taken from Kenneth French's website.⁹

Following Chen, Novy-Marx, and Zhang (2011), the book value is equal to the book value of shareholder equity, plus balance sheet deferred taxes and investment tax credits (item TXDITC, if available), minus the book value of preferred stock. Shareholder equity is measured using stockholders' equity (item SEQ). If the variable is not available, I use common equity (item CEQ) plus the carrying value of preferred stock (item PSTK). If both shareholder equity and common equity are missing, I use total assets (item AT) minus total liabilities (item LT). The book value of preferred stock is measured using the redemption value (item PSTKR, if available). If the quantity is missing, I use the liquidation value (item PSTKL, if available). The cash-to-assets ratio ($CASH$) is the value of corporate cash holdings (item CHE) over the value of the firm's total assets (item AT). The book leverage (LEV) is the sum of long-term debt (item DLTT) and debt in current liabilities (item DLC) over the value of the firm's total assets (item AT). Net leverage (NL) is defined as the difference between the book leverage and the cash-to-assets ratio. I use the SIC code in Compustat to exclude from the data set utilities (SIC codes between 4900 and 4949) and financial companies (SIC codes between 6000 and 6999) because these sectors are subject to heavy regulation. In addition, I drop observations with non-positive book value of equity and negative total assets. I also require that the cash-to-assets ratio and the leverage ratio are in the interval $[0, 1]$.

Companies in CRSP are matched with companies in Compustat that have the same value for the security identifier PERMNO. Accounting data precede portfolio formation by at least six months. The book-to-market ratio (BM) is equal to the book value of equity divided by the market value of equity at portfolio formation.

⁸The CRSP codes for poor performance delists can be found in the CRSP Delisting Returns guide, at http://www.crsp.com/crsp/resources/papers/crsp_white_paper_delist_returns.pdf.

⁹ http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

3.2. Net leverage factor and equity returns

Following George and Hwang (2010), I form portfolios at a monthly frequency that are held for T months. The overall return of the investment strategy at time t is given by the contributions of the single portfolios formed at time $t - j$, $j = 1, \dots, T$. In order to isolate the contribution of the portfolio formed in month $t - j$, I run the following cross-sectional regression:

$$\begin{aligned} R_{it} = & \alpha_{jt} + b_{0,jt}R_{i,t-1} + b_{1,jt} \log(Size_{i,t-1}) + b_{2,jt} \log(BM_{i,t-1}) \\ & + b_{3,jt}Loser_{i,t-j} + b_{4,jt}Winner_{i,t-j} + b_{5,jt}LN_{i,t-j} + b_{6,jt}HN_{i,t-j} \\ & + b_{7,jt}HC_{i,t-j} + b_{8,jt}LC_{i,t-j} + b_{9,jt}LL_{i,t-j} + b_{10,jt}HL_{i,t-j} + \varepsilon_{ijt} \quad j = 1 \dots T. \end{aligned}$$

The dependent variable is the return to stock i in month t . The independent variables can be separated into two categories. The first is made up of variables that are known to affect returns. These are the market capitalization of the firm in the previous month ($Size_{i,t-1}$) and the book-to-market ($BM_{i,t-1}$). George and Hwang (2010) suggest also including the previous month's return ($R_{i,t-1}$) to control for bid-ask bounce. All the control variables are expressed in deviation from their cross-sectional mean¹⁰.

The second category includes dummies related to portfolio strategies. The first two, *Winner* and *Loser*, control for momentum and are constructed following George and Hwang (2004). The third and fourth dummies, $LN_{i,t-j}$ and $HN_{i,t-j}$, refer to portfolio strategies formed on net leverage. $HN_{i,t-j}$ takes value 1 if stock i was in the top 20% of the net leverage distribution at time $t - j$ and zero otherwise. $LN_{i,t-j}$ takes value 1 if stock i was in the bottom 20% of the net leverage at time $t - j$ and zero otherwise. A similar interpretation holds for $LC_{i,t-j}$ (low cash-to-asset portfolio), $HC_{i,t-j}$ (high cash-to-asset portfolio), $LL_{i,t-j}$ (low leverage portfolio), and $HL_{i,t-j}$ (high leverage portfolio). I add the last four dummies to compare my results with those in George and Hwang (2010) and with a cash-based investment strategy.

The overall contribution of LN portfolios to the total return at time t is given by a simple average over all the $b_{5,jt}$ coefficients, namely $b_{5,t} = \frac{1}{T} \sum_{j=1}^T b_{5,jt}$. The average intercept α_t can be interpreted as the excess return of a portfolio that each month hedges the effect on stock returns of all the other independent variables. As a consequence, $\alpha_t + b_{5,t}$ is the return of a strategy that each month takes a long position on the low net leverage firms. Finally, $b_{5,t} - b_{6,t}$ is the excess return of

¹⁰The procedure suggested by George and Hwang (2010) can be considered complementary to the one used by Fama and French (2008) to create abnormal returns (i.e., returns adjusted for characteristics known to affect them.)

a strategy long in the low net leverage firms and short in the high net leverage firms.¹¹

In Table 1, the regression coefficients are the time series averages of the monthly contribution from January 1967 to December 2010 and the corresponding t-statistics are evaluated dividing the time series average by their time series standard errors. In all the regressions, the coefficients on the control variables have the expected sign and all are significant. The coefficients on the portfolios formed on net leverage have signs that agree with the model’s predictions. In the data, low net leverage firms earn a higher average return than high net leverage firms after controlling for size, book-to-market, and bid-ask bounce (0.47% per month and equal to the difference between 0.24% and -0.23%). Regression (b) shows that the spread between high cash-to-asset and low cash-to-asset firms is positive (0.39% per month.), thus confirming the positive relation between cash holdings and realized returns documented in Palazzo (2012). In the last regression, I replicate the analysis in George and Hwang (2010) by looking at portfolios that discriminate between low leverage firms and high leverage firms. I also find that firms with lower leverage earn a higher average return (0.40% per month), a result that confirms their findings.

Using the results in Table 1, I can build the excess return of a strategy long in the low net leverage firms and short in the high net leverage firms, namely the difference each month between the coefficients $b_{5,t}$ and $b_{6,t}$ in regression (a) of Table 1. Table 2 shows that the net leverage-based excess return is not a linear combination of other excess returns (factors) used in empirical asset pricing to risk-adjust equity returns. In Panel A, I regress the net leverage excess return on the Carhart four-factor model. The intercept, which has the interpretation of a risk-adjusted return, is positive (0.82% per month) and statistically different from zero. The only factors that have a significant coefficient are the market and value factors. In Panel B, I use the Chen, Novy-Marx, and Zhang (2011) factor model and again the intercept is positive (0.86% per month) and statistically different from zero. Notice that both the profitability factor (ROE) and the investment factor (INV) have negative coefficients that are statistically different from zero. When I use all the factors (Panel C), the R-squared increases to almost 50%, while the risk-adjusted return is still significant.

In Tables 3 and 4, I report the characteristics and correlations of excess returns based on stocks sorted on net leverage, cash holdings, and book leverage¹², the Momentum factor, the Fama and French (1993) factors, and the Chen, Novy-Marx, and Zhang (2011) factors for the period January

¹¹For a detailed discussion of the parameters’ interpretations as returns, see chapter 9 in Fama (1976)

¹²The cash holdings and book leverage excess returns are constructed following the same procedure as the net leverage excess returns.

Table 1: **Portfolio Analysis**

	Raw Returns					
	(a)		(b)		(c)	
Intercept	1.03	(4.22)	1.00	(4.08)	1.05	(4.26)
Controls						
R_{t-1}	-0.06	(-17.59)	-0.06	(-17.51)	-0.06	(-17.45)
Size	-0.17	(-4.06)	-0.16	(-3.96)	-0.17	(-4.11)
Book-to-market	0.34	(5.28)	0.35	(5.48)	0.32	(4.81)
Portfolios						
Loser	-0.26	(-1.61)	-0.28	(-1.74)	-0.25	(-1.50)
Winner	0.58	(8.35)	0.58	(8.42)	0.58	(8.28)
Low Net Leverage (LN)	0.24	(2.89)				
High Net Leverage (HN)	-0.23	(-3.93)				
High Cash (HC)			0.27	(3.15)		
Low Cash (LC)			-0.12	(-2.44)		
Low Leverage (LL)					0.15	(2.91)
High Leverage (HL)					-0.25	(-4.10)

For each month between January 1967 and December 2010, I estimate a cross-sectional regression where R_{it} is the return in month t to stock i and $R_{i,t-1}$ is the previous month's return.

$$\begin{aligned}
R_{it} = & \alpha_{jt} + b_{0,jt}R_{i,t-1} + b_{1,jt}\log(Size_{i,t-1}) + b_{2,jt}\log(BM_{i,t-1}) \\
& + b_{3,jt}Loser_{i,t-j} + b_{4,jt}Winner_{i,t-j} + b_{5,jt}LN_{i,t-j} + b_{6,jt}HN_{i,t-j} \\
& + b_{7,jt}HC_{i,t-j} + b_{8,jt}LC_{i,t-j} + b_{9,jt}LL_{i,t-j} + b_{10,jt}HL_{i,t-j} + \varepsilon_{ijt} \quad j = 1...T.
\end{aligned}$$

$Size_{i,t-1}$ is the market capitalization of the firm in the previous month and $BM_{i,t-1}$ is the book-to-market. $R_{i,t-1}$, $Size_{i,t-1}$ and $BM_{i,t-1}$ are taken in deviation from the correspondent cross-sectional mean. *Winner* and *Loser* are dummy variables that control for momentum. Let $P_{i,t-j}$ the price of stock i at time $t-j$ and $H_{i,t-j}$ the highest price of stock i during the period from $t-j-T$ to $t-j$, *Winner* (*Loser*) is equal to 1 at time $t-j$ if the stock is in the top (bottom) 20% of the $\frac{P_{i,t-j}}{H_{i,t-j}}$ distribution. $HN_{i,t-j}$ takes value 1 if stock i was in the top 20% of the net leverage distribution at time $t-j$ and zero otherwise. $LN_{i,t-j}$ takes value 1 if stock i was in the bottom 20% of the net leverage distribution at time $t-j$ and zero otherwise. A similar interpretation holds for $LC_{i,t-j}$ (low cash-to-asset portfolio), $HC_{i,t-j}$ (high cash-to-asset portfolio), $LL_{i,t-j}$ (low leverage portfolio), and $HL_{i,t-j}$ (high leverage portfolio). The reported coefficients are the time series averages of the cross-sectional averages taken over the $j = 1, \dots, 6$ holding periods. The corresponding t-statistics are evaluated dividing the time series average by their time series standard errors as suggested in Fama and MacBeth (1973)

1972 to December 2010. The net leverage and cash holdings excess returns are characterized by a high kurtosis that is comparable to that of the Momentum factor. On the other hand, their skewness is large and positive. All of the excess returns in Table 3 are statistically different from zero except for the size-based factor SMB. Table 4 shows that the net leverage, cash holdings, and book leverage excess returns have relatively large negative correlations with the value and profitability factors. More importantly, Table 4 shows that the net leverage excess return is very highly correlated with both the cash holding and the leverage excess returns. Figure 4 reports the cumulative returns generated by the three investment strategies. As we can see, the cumulative returns generated by the net leverage-based investment strategy are almost indistinguishable from both the cash holding-based and the leverage-based investment strategies.

The results in this subsection show a robust negative correlation between net leverage and

Table 2: **Risk-adjusted net leverage excess returns**

	constant	MKT	SMB	HML	MOM	INV	ROE	R-squared
Panel A	0.82 (4.36)	-0.12 (-3.52)	0.11 (1.23)	-0.56 (-7.04)	-0.05 (-0.71)			0.33
Panel B	0.86 (3.15)	-0.06 (-1.29)				-0.23 (-1.99)	-0.33 (-2.51)	0.16
Panel C	1.00 (5.09)	-0.14 (-5.55)	-0.03 (-0.74)	-0.57 (-10.79)	0.05 (0.83)	0.11 (1.21)	-0.36 (-4.77)	0.45

The table reports the coefficients, the t-statistics and the R-squared of a linear regression of the net leverage excess returns on the Momentum and the Fama and French (1993) factors (Panel A), the Chen, Novy-Marx, and Zhang (2011) factors (Panel B), and the factors in Panel A and Panel B combined (Panel C). The sample period is from January 1972 to December 2010

Table 3: **Excess returns: summary statistics**

	Mean	t-stat	Median	Std. Dev.	Kurtosis	Skewness
Net Leverage	0.51	3.73	0.36	2.97	15.37	1.77
Cash	0.42	3.18	0.19	2.87	16.95	2.18
Leverage	0.44	4.26	0.40	2.22	8.26	0.89
MKT	0.46	2.14	0.86	4.68	5.07	-0.58
SMB	0.22	1.46	0.06	3.21	9.46	0.59
HML	0.43	2.98	0.38	3.09	5.25	-0.03
MOM	0.73	3.46	0.88	4.58	13.49	-1.47
INV	0.41	5.06	0.31	1.76	4.31	0.18
ROE	0.71	4.43	0.81	3.47	9.03	-0.70

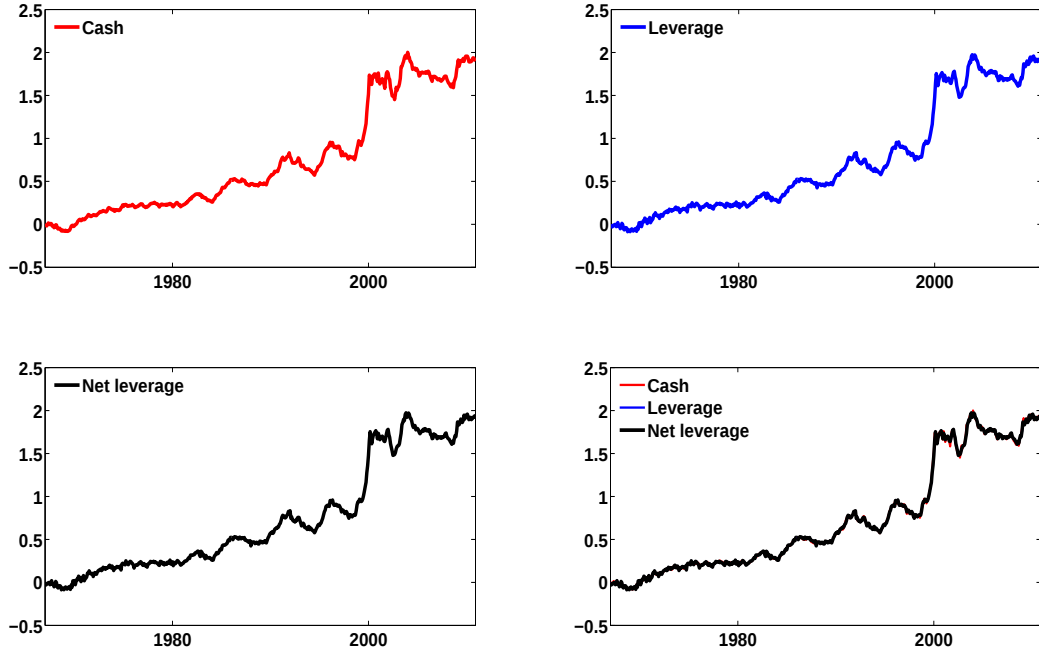
The table reports the summary statistics of the net leverage, cash-to-asset ratio, and leverage-based excess returns together with the Fama and French factors (MKT, SMB, and HML), the momentum factor (MOM), the investment factor (INV), and the profitability factor (ROE) over the period January 1972 to December 2010. The first column reports the time-series average and the second column the corresponding t-statistics. The third and fourth columns report the median and standard deviation, respectively. The last two columns report the kurtosis and the skewness.

Table 4: **Excess returns: correlations**

Cash	1.00							
Leverage	0.77***	1.00						
Net Leverage	0.92***	0.92***	1.00					
MKT	0.18	-0.08	0.04	1.00				
SMB	0.32**	0.07	0.21	0.27	1.00			
HML	-0.55***	-0.50***	-0.54***	-0.33***	-0.24**	1.00		
MOM	-0.04	0.05	0.05	-0.14	-0.01	-0.16	1.00	
INV	-0.17	-0.15**	-0.14	-0.25***	-0.03	0.41*	0.15	1.00
ROE	-0.48***	-0.22	-0.37**	-0.25**	-0.40***	0.10	0.40**	0.07

The table reports the correlation among the variables summarized in Table 3 over the period January 1972 to December 2010. The 1%, 5%, and 10% significance levels are denoted with ***, **, and *, respectively.

Figure 4: Net Leverage Factor and other factors: 01/1972 - 12/2010



This figure depicts the cumulative return of a strategy that discriminates between high cash-to-assets ratio firms and low cash-to-assets ratio firms (top left panel), a strategy that discriminates between low leverage firms and high leverage firms (top right panel), and a strategy that discriminates between low net leverage firms and high net leverage firms (bottom left panel) over the period January 1967 to December 2010. The bottom right panel reports all of the excess returns in a single graph.

realized equity returns. In addition, cash can be considered negative debt for investment purposes because the cumulative returns of the three investment strategies based on net leverage, cash holdings, and leverage are virtually the same. Such a result unifies empirical studies in asset pricing that so far have separately studied the effects of leverage and cash holding policies on equity returns.

3.3. Net leverage sorted portfolios

In this subsection, I perform a portfolio analysis in the spirit of Fama and French (1992). In June of each year, I form ten portfolios sorted using net leverage data available at least six months prior to portfolio formation and then I evaluate the subsequent twelve months returns starting in July. Table 5 reports some key characteristics of the ten net leverage sorted portfolios. Not surprisingly, net leverage is positively correlated with book leverage and negatively correlated with cash holdings. The book-to-market ratio is monotonically increasing in net leverage. High net leverage firms tend to be value firms, while low net leverage firms have a larger part of their value tied to growth options and tend to be growth firms. Table 5 shows that there is a hump-shaped relation between

net leverage and the market value and that the average market capitalization between the bottom and top decile firms is not statistically different.

Table 6 reports the raw and risk-adjusted equity returns in excess of the risk-free rate generated by the ten net-leverage sorted portfolios. The difference in raw returns, both equally and value weighted, is negative as predicted by the model, albeit not statistically significant. The lack of significance might be due to the fact that high net leverage firms are also value firms and they pay a premium with respect to low net leverage firms that are also growth firms. This fact could reduce the difference in returns between the top and the bottom portfolios.

When I risk-adjust the realized returns using the Carhart four-factor model (columns 3 and 4), the difference in risk-adjusted returns is negative (1.08% and 0.75% per month for the equally weighted and value weighted portfolios, respectively) and statistically different for zero. The main result in columns 3 and 4 of Table 6 is that the standard risk-adjustment model is not able to explain the variation in equity returns across the net leverage sorted portfolios. In columns 5 and 6, I risk-adjust equity returns adding to the Carhart four-factor model a fifth net leverage-based factor. This factor is the intercept plus the residuals in equation in Panel C of Table 2¹³. When I add this fifth factor, the difference in risk-adjusted returns between the bottom and top portfolios becomes not significant in the equally weighted case and positive and significant in the value weighted case.

Figure 5 reports the risk-adjusted returns (intercept) and the factor loadings for the Carhart four-factor model and the Carhart four-factor model augmented with the net leverage-based factor. Since the net leverage-based factor has no exposure to the market (MKT), size (SMB), book-to-market (HML), and momentum (MOM) factors, the loadings on the Carhart (1997) four-factors are virtually the same across the two linear factor models. For this reason, I only report the factor loadings for the augmented Carhart four-factor model.

The top left panel in Figure 5 reports the risk-adjusted returns generated by the Carhart four-factor model for the equally weighted and value weighted case (lines *EWI* and *VWI*, respectively) and the augmented Carhart four-factor model for the equally weighted and value weighted case (lines *EWII* and *VWII*, respectively). As we can see, the inclusion of the net leverage based factor almost reverses the negative relation between risk-adjusted returns and net leverage. Figure 5 shows that the loadings on the SMB (top right panel) and MOM (central bottom panel) factors do

¹³In this way, the net-leverage based factor has no exposure to the sources of risk proxied by the other factors in Table 2.

Table 5: Net leverage sorted portfolios: characteristics

Portfolio	Net Leverage	Cash	Leverage	Book-to-Market	Size	Obs.
1	-0.5603	0.5845	0.0242	0.6675	3.9424	360
2	-0.2752	0.3246	0.0494	0.7562	4.2766	359
3	-0.1274	0.2066	0.0792	0.8251	4.4357	360
4	-0.0218	0.1375	0.1157	0.9106	4.471	360
5	0.0643	0.0971	0.1614	0.9625	4.5978	359
6	0.1417	0.0721	0.2138	1.0376	4.7062	360
7	0.2137	0.0564	0.2701	1.0427	4.6917	359
8	0.2861	0.0463	0.3324	1.1493	4.5486	359
9	0.3733	0.0403	0.4136	1.2189	4.2832	359
10	0.5422	0.0364	0.5786	1.2978	3.9129	356
10-1	1.1025***	-0.5563***	0.5544***	0.6303***	-0.0295	

The table reports the characteristics across the ten net leverage-sorted portfolios. The column *Net Leverage* reports the difference between the leverage ratio and the cash-to-assets ratio. The column *Cash* reports the cash-to-asset ratio defined as the value of corporate cash holdings (item CHE) over the value of the firm's total assets (item AT). The column *Leverage* reports the leverage ratio defined as the sum of long-term debt (item DLTT) and debt in current liabilities (item DLC) over the value of the firm's total assets (item AT). The column *Book-to-Market* reports the book-to-market ratio. Following Chen, Novy-Marx, and Zhang (2011), the book value is equal to the book value of shareholder equity, plus balance sheet deferred taxes and investment tax credits (item TXDITC, if available), minus the book value of preferred stock. Shareholder equity is measured using stockholder equity (item SEQ). If the variable is not available, I use common equity (item CEQ) plus the carrying value of preferred stock (item PSTK). If both shareholder equity and common equity are missing, I use total assets (item AT) minus total liabilities (item LT). The book value of preferred stock is measured using the redemption value (item PSTKR, if available). If the quantity is missing, I use liquidation value (item PSTKL, if available). The book-to-market ratio (*BM*) is equal to the book value of equity by the market value of equity at portfolio formation. The column *Size* reports the market value of equity at portfolio formation. The last column reports the number of stocks in each portfolio. All of the reported values are time-series averages of cross-sectional means. The last row reports the difference in average characteristics between the top decile and the bottom decile. Portfolios are rebalanced annually at the beginning of June over the time period 1972-2010. The 1%, 5%, and 10% significance levels are denoted with ***, **, and *, respectively.

Table 6: Net leverage sorted portfolios: raw and risk-adjusted returns

Portfolio	Raw EW	Raw VW	Carhart EW	Carhart VW	Carhart Aug. EW	Carhart Aug. VW
	(1)	(2)	(3)	(4)	(5)	(6)
1	0.9669	0.5588	0.7597	0.2789	0.2162	-0.2857
2	0.9031	0.6886	0.561	0.339	0.1058	-0.1345
3	0.9274	0.735	0.5138	0.3317	0.3305	0.1093
4	0.9268	0.6988	0.4432	0.2315	0.3803	0.1268
5	0.9397	0.7447	0.3552	0.1795	0.3853	0.1896
6	0.8942	0.7314	0.283	0.1182	0.4102	0.1967
7	0.8252	0.6968	0.1798	0.0499	0.3864	0.2119
8	0.8176	0.6392	0.1147	-0.0693	0.4129	0.1921
9	0.6639	0.5095	-0.0757	-0.2247	0.3596	0.1419
10	0.4841	0.3433	-0.3198	-0.473	0.31	0.0646
10-1	-0.4828	-0.2155	-1.0795***	-0.7519***	0.0938	0.3503***

This table reports the raw and risk-adjusted returns for the ten net leverage sorted portfolios. Columns 1 and 2 report the average realized equity returns in excess of the risk-free rate for the equally weighted and value weighted portfolios, respectively. Columns 3 and 4 report the risk-adjusted equity returns generated by the Carhart97 four-factor model for the equally weighted and value weighted portfolios, respectively. The reported risk-adjusted equity return for portfolios $i = 1, \dots, 10$ is the intercept of the monthly time-series linear regression below:

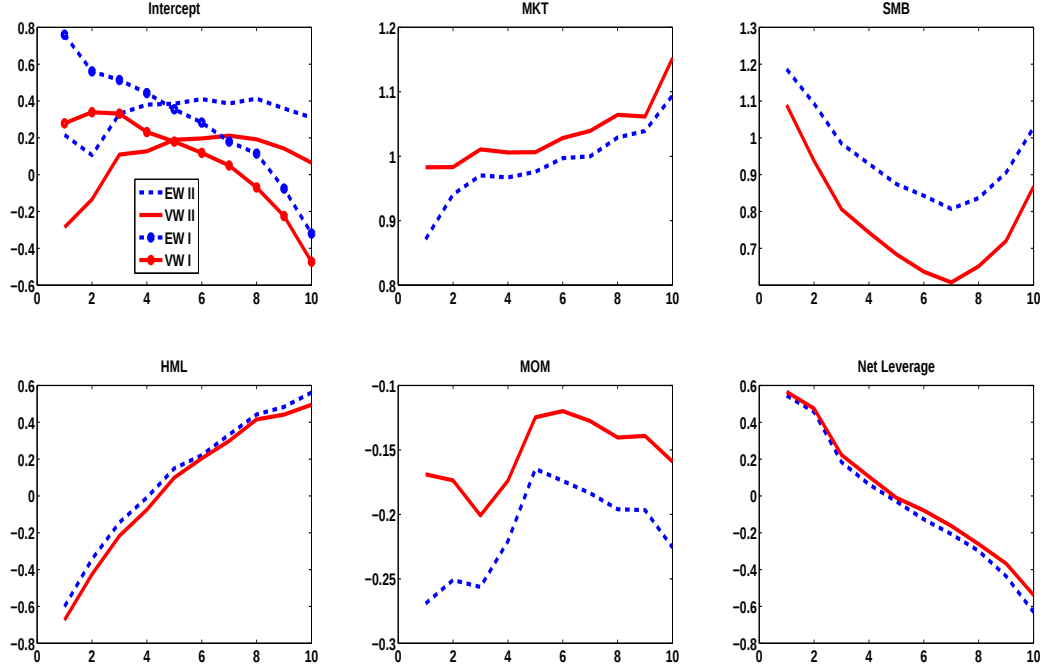
$$r_t^i - r_t^f = \alpha + \beta_{MKT}(MKT_t - r_t^f) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \beta_{MOM}MOM_t + \varepsilon_t^i.$$

Columns 5 and 6 report the risk-adjusted equity returns generated by the Carhart four-factor model augmented with the net leverage based factor for the equally weighted and value weighted portfolios, respectively. In this case, the reported risk-adjusted equity return for portfolios $i = 1, \dots, 10$ is the intercept of the monthly time-series linear regression below:

$$r_t^i - r_t^f = \alpha + \beta_{MKT}(MKT_t - r_t^f) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \beta_{MOM}MOM_t + \beta_{LNMHNLNMHN_t} \varepsilon_t^i.$$

The last row reports the difference in raw and risk-adjusted equity returns between the top and bottom portfolios. Portfolios are rebalanced annually at the beginning of June over the time period 1972-2010. The 1%, 5%, and 10% significance levels are denoted with ***, **, and *, respectively. The t-statistics are evaluated following Newey and West (1987) and using 12 lags.

Figure 5: Net Leverage Sorted Portfolios: Factor Loadings



This figure depicts the intercept and the factor loadings relative to the regressions reported in Table 6. The top left panel reports the risk-adjusted returns generated by the Carhart four-factor model for the equally weighted and value weighted case (lines *EWI* and *VWI*, respectively) and the augmented Carhart four-factor model for the equally weighted and value weighted case (lines *EWII* and *VWII*, respectively). The reported factor loadings for the equally weighted (dotted blue line) and value weighted (solid red line) cases are generated using the augmented Carhart four-factor model. The ones generated using the Carhart four-factor model look almost identical and are not reported.

not follow a clear increasing or decreasing pattern. On the other hand, factor loadings are increasing in net leverage for MKT (central top panel) and HML (left bottom panel) and decreasing for the net leverage based factor (right bottom panel). The loading on the MKT factor for the bottom portfolio is 0.87 (0.98) in the equally weighted case (value weighted case) with a standard deviation of 0.09 (0.04), while the loading of the top portfolio is 1.09 (1.15) with a standard deviation of 0.03 (0.03). The average value of the MKT factor over the period January 1972 to December 2010 is equal to 0.46% per month (see Table 3); it follows that in the equally weighted (value weighted) case this factors generates a positive spread between the high and low net leverage portfolios equal to $0.22 \times 0.46\% = 0.10\%$ ($0.17 \times 0.46\% = 0.08\%$) per month. The differences in factor loadings are much larger for the HML and the net leverage based factors. The loading on the HML factor for the bottom portfolio is -0.60 (-0.67) in the equally weighted case (value weighted case) with a standard deviation of 0.13 (0.10), while the loading on the top portfolio is 0.56 (0.50) with a standard deviation of 0.07 (0.07). The loading on the net leveraged based factor for the bottom portfolio is 0.54 (0.57) in the equally weighted case (value weighted case) with a standard deviation

Table 7: **Credit ratings**

	Investment Grade										
rating	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	
numerical value	2	4	5	6	7	8	9	10	11	12	
	Non Investment Grade										
rating	BB+	BB	BB-	B+	B	B-	CCC+	CCC	CCC-	CC	C
numerical value	13	14	15	16	17	18	19	20	21	23	24

The table reports the values taken by the variable S&P Domestic Long Term Issuer Credit Rating (item SPLTICRM in Compustat) together with the corresponding numerical values.

of 0.12 (0.09), while the loading on the top portfolio is -0.63 (-0.54) with a standard deviation of 0.08 (0.07). It follows that the HML factor generates a positive differential between the top and the bottom portfolios in the equally weighted (value weighted) case equal to $1.16 \times 0.43\% = 0.50\%$ ($1.17 \times 0.43\% = 0.50\%$) per month, while the net leverage factor generates a negative differential between the top and the bottom in the equally weighted (value weighted) case equal to $-1.17 \times 1.00\% = -1.17\%$ ($-1.11 \times 1.00\% = -1.11\%$) per month.

The portfolio analysis shows that although high net leverage stocks are value stocks, they do not earn an excess returns over low net leverage (growth) stocks. The reason might be the presence of a source of risk proxied by the net leverage based factor and not related, by construction, to the sources of risk proxied by the other factors. High net leverage (value) firms are less exposed to this source of risk than high net leverage (growth) firms and for this reason they generate realized returns lower than that implied by their exposure to the HML factor.

3.4. Net leverage sorted portfolios and credit ratings

To test the model's implications regarding net leverage, credit spreads, and equity returns, I restrict the sample to firms that report data on credit rating. I use credit ratings as a proxy for credit spreads mainly for data availability reasons. Using the S&P Domestic Long Term Issuer Credit Rating (item SPLTICRM) provided by Compustat, I can start forming portfolios in January 1986¹⁴.

Table 7 reports the letter values (item SPLTICRM) and the corresponding numerical value assigned by Compustat. I exclude from the sample companies rated *D* (default) or *SD* (selective default). I use two measures of crediting rating in the portfolio analysis: (i) the simple average of the numerical value provided by Compustat; (ii) the percentage of non-investment-grade firms.

¹⁴Using the bond data provided by the Trade Reporting and Compliance Engine (TRACE) allows portfolio formation starting in 2002. To have a longer time series, I consider only firms that report the item SPLTICRM.

Table 8 reports the characteristics of the net leverage-sorted portfolios for the subsample of firms that have a credit rating value. The average portfolio is made up by 78 observations; it follows that around 21% of the observations in our original sample have an assigned credit rating. Rated firms are on average larger and have a net leverage distribution shifted to the right because they have, on average, a larger leverage and a smaller cash-to-asset ratio. Unlike the full sample, rated firms show a significant negative relation between market capitalization (Size) and net leverage. Even if the relation between credit ratings and net leverage is not monotonic, firms in the top decile have a significantly larger numerical credit rating¹⁵.

Table 9 reports the portfolio analysis results. The main findings documented in the previous subsection survive in the smaller sample of credit rated firms. The difference in raw returns between the top and bottom portfolios is negative but not significantly different from zero. When returns are risk-adjusted using the Carhart four-factor model, the difference in risk-adjusted returns is negative and significant in both the equally weighted and the value weighted cases. The difference in risk-adjusted equity returns between the high net leverage and low net leverage portfolios becomes not significantly different from zero when the net leverage based factor is included in the time series regression. Note that, unlike in Table 6, the results for equally weighted portfolios are very similar to those for value weighted portfolios. As noted in Fama and French (2008), the differences in average returns between equally weighted and value weighted portfolios becomes larger when micro cap firms represent a large fraction of the sample. The comparison of the results in Tables 5 and 8 makes clear that micro cap firms do not represent a large fraction of credit rated firms.

The three-period model predicts a negative relation between credit spreads and expected returns, all else being equal. In Figure 6, I compare the risk-adjusted returns in columns 3 and 4 of Table 9 with the two proxies for credit ratings. All the variable are standardized to facilitate the comparison. The slope of the regression line is the correlation coefficient between the credit rating measure and the risk-adjusted returns. The top panels use the numerical credit rating, while the bottom panels use the percentage of non-investment grade firms. The left panels report value-weighted risk-adjusted returns, while the right panels report value-weighted risk-adjusted returns. In all four cases, the slope is negative and significantly different from zero¹⁶, thus giving empirical support to the negative relation between credit spreads and equity returns predicted by the model.

¹⁵This results confirms the findings in Acharya, Davydenko, and Strebulaev (2011) that document a non-monotonic relation between credit spreads and cash holdings.

¹⁶Starting from the top left panel and going clockwise, the slope takes the values of -0.87, -0.82, -0.82, and -0.77, respectively.

Table 8: Net leverage sorted portfolios and credit ratings: characteristics

Port.	Net Lev.	Cash	Lev.	BM	Size	Rating I	Rating II	Obs.
1	-0.1682	0.2913	0.1230	0.5564	7.7628	11.4641	0.4521	78
2	0.0381	0.1321	0.1702	0.6424	7.7776	10.5288	0.3239	78
3	0.1170	0.0924	0.2094	0.6952	7.6514	10.6399	0.3159	78
4	0.1756	0.0700	0.2456	0.8071	7.5365	10.9932	0.3326	78
5	0.2262	0.0551	0.2814	0.8553	7.4164	11.3534	0.3579	78
6	0.2737	0.0463	0.3200	0.9335	7.3101	11.6879	0.3954	78
7	0.3235	0.0440	0.3675	0.9267	7.0494	12.4428	0.4945	78
8	0.3821	0.0385	0.4206	1.0420	6.7052	13.3307	0.6213	78
9	0.4629	0.0409	0.5038	1.3879	6.3067	14.2009	0.7582	78
10	0.6129	0.0347	0.6475	1.3851	5.7006	15.4193	0.8683	77
10-1	0.7811***	-0.2566***	0.5245***	0.8287***	-2.0622***	3.9552***	0.4162***	

The table reports the characteristics across the ten net leverage-sorted portfolios for the subset of firms that have an assigned credit rating. The column *Net Leverage* reports the difference between the leverage ratio and the cash-to-assets ratio. The column *Cash* reports the cash-to-asset ratio defined as the value of corporate cash holdings (item CHE) over the value of the firm's total assets (item AT). The column *Leverage* reports the leverage ratio defined as the sum of long-term debt (item DLTT) and debt in current liabilities (item DLC) over the value of the firm's total assets (item AT). The column *Book-to-Market* reports the book-to-market ratio. Following Chen, Novy-Marx, and Zhang (2011), the book value is equal to the book value of shareholder equity, plus balance sheet deferred taxes and investment tax credits (item TXDITC, if available), minus the book value of preferred stock. Shareholder equity is measured using stockholder equity (item SEQ). If the variable is not available, I use common equity (item CEQ) plus the carrying value of preferred stock (item PSTK). If both shareholder equity and common equity are missing, I use total assets (item AT) minus total liabilities (item LT). The book value of preferred stock is measured using the redemption value (item PSTKR, if available). If the quantity is missing, I use the liquidation value (item PSTKL, if available). The book-to-market ratio (*BM*) is equal to the book value of equity by the market value of equity at portfolio formation. The column *Size* reports the market value of equity at portfolio formation. The column *Rating I* reports the numerical value of the variable S&P Domestic Long Term Issuer Credit Rating (item SPLTICRM). The column *Rating II* reports the percentage of observations with non-investment grade credit ratings. The last column reports the number of stocks in each portfolio. All of the reported values are time-series averages of cross-sectional means. The last row reports the difference in average characteristics between the top decile and the bottom decile. Portfolios are rebalanced annually at the beginning of June over the time period 1986-2010. The 1%, 5%, and 10% significance levels are denoted with ***, **, and *, respectively.

Table 9: Net leverage sorted portfolios and credit ratings: raw and risk-adjusted returns

Portfolio	Raw EW	Raw VW	Carhart EW	Carhart VW	Carhart Aug. EW	Carhart Aug. VW
	(1)	(2)	(3)	(4)	(5)	(6)
1	0.7645	0.7493	0.3439	0.3265	0.1317	0.1180
2	0.7046	0.6892	0.1465	0.1355	0.2076	0.1948
3	0.8363	0.8033	0.2160	0.1849	0.4198	0.3652
4	0.8391	0.8162	0.1690	0.1664	0.3287	0.3162
5	0.8059	0.7903	0.1291	0.1082	0.3469	0.3250
6	0.6893	0.6903	0.0002	0.0087	0.2826	0.2570
7	0.5665	0.5852	-0.1783	-0.1529	0.1032	0.1053
8	0.7016	0.7170	-0.0205	-0.0007	0.3268	0.3236
9	0.5471	0.5487	-0.1604	-0.1664	0.1571	0.1563
10	0.4796	0.6075	-0.3161	-0.1833	0.1258	0.2068
10-1	-0.2849	-0.1418	-0.6601***	-0.5098***	-0.0059	0.0888

This table reports the raw and risk-adjusted returns for the ten net leverage sorted portfolios relative to the subset of firms that have an assigned credit rating. Columns 1 and 2 report the average realized equity returns in excess of the risk-free rate for the equally weighted and value weighted portfolios, respectively. Columns 3 and 4 report the risk-adjusted equity returns generated by the Carhart four-factor model for the equally weighted and value weighted portfolios, respectively. The reported risk-adjusted equity return for portfolios $i = 1, \dots, 10$ is the intercept of the monthly time-series linear regression below:

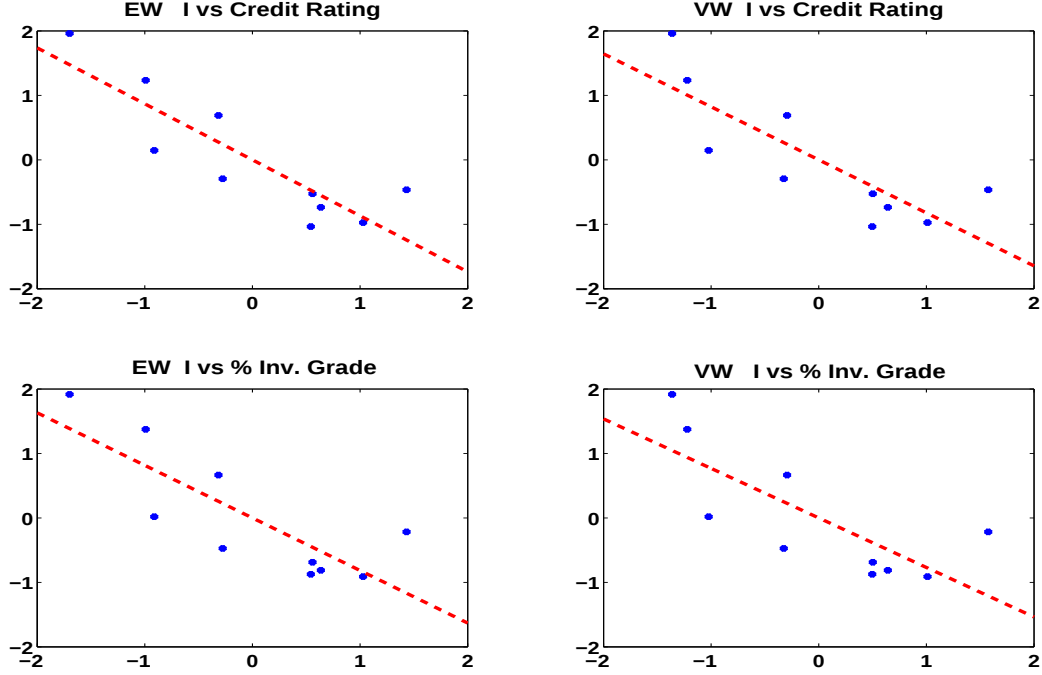
$$r_t^i - r_t^f = \alpha + \beta_{MKT}(MKT_t - r_t^f) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \beta_{MOM}MOM_t + \varepsilon_t^i.$$

Columns 5 and 6 report the risk-adjusted equity returns generated by the Carhart four-factor model augmented with the net leverage based factor for the equally weighted and value weighted portfolios, respectively. In this case, the reported risk-adjusted equity return for portfolios $i = 1, \dots, 10$ is the intercept of the monthly time-series linear regression below:

$$r_t^i - r_t^f = \alpha + \beta_{MKT}(MKT_t - r_t^f) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \beta_{MOM}MOM_t + \beta_{LNMHN}LNMHN_t + \varepsilon_t^i.$$

The last row reports the difference in raw and risk-adjusted equity returns between the top and bottom portfolios. Portfolios are rebalanced annually at the beginning of June over the time period 1986-2010. The 1%, 5%, and 10% significance levels are denoted with ***, **, and *, respectively. The t-statistics are evaluated following Newey and West (1987) and using 12 lags.

Figure 6: **Risk-Adjusted Returns and Credit Ratings (Standardized)**



This figure reports the returns risk-adjusted using the Carhart (1997) four factor model on the X-axis and the variables summarizing credit ratings on the Y-axis, all the variables are standardized. The top panels depicts the result using the credit rating numerical value, while the bottom panel depicts the result using the percentage of non-investment grade firms. The left panels refer to equally weighted portfolios, while the right panels to value weighted portfolios. The slope of the regression line is the correlation coefficient between the two variables.

3.5. Credit-ratings sorted portfolios

In the last part of the empirical analysis, I test if the net leverage-based factor is able to account for the variability in returns across credit ratings sorted portfolios. In Table 10, I report the characteristics of four credit-ratings portfolios. I group stocks to obtain a similar average number of observations across the different categories. In addition, I eliminate firms with a rating lower than B- to mitigate the effect on my results of the poor performance of stocks close to default. On average, firms with a rating lower than B- represent 2.6% of the total observations and 0.17% of the overall market capitalization at portfolio formation¹⁷.

In the first portfolio (lowest credit risk) I include firms with a very strong or strong repayment capacity (ratings from AAA to A-). The second portfolio includes firms with an adequate repayment capacity (BBB+ to BBB). The first two portfolios include the subset of investment grade firms, while non-investment grade firms are found in the third and fourth portfolios. Firms with a less adequate repayment capacity (BB+ to BB-) are included in the third portfolio and firms with a

¹⁷Avramov, Chordia, Jostova, and Philipov (2009) and Avramov, Chordia, Jostova, and Philipov (2012) explore the effect of firms close to default on the equity return differential in credit ratings-sorted portfolios.

Table 10: Credit ratings sorted portfolios: characteristics

Port.	Rep. capacity	Net Lev.	Cash	Lev.	BM	Size	Rat. I	Rat. II	N
1	Strong (AAA; A-)	0.1518	0.0781	0.2299	0.4692	8.9368	7.1917	0	195
2	Adequate (BBB+; BBB)	0.2234	0.065	0.2885	0.7307	7.6431	11.0266	0	198
3	Less adequate (BB+; BB-)	0.283	0.0866	0.3696	0.8622	6.4039	14.1979	1	217
4	Vulnerable (B+; B-)	0.3131	0.1206	0.4337	1.2463	5.434	16.5455	1	160
4-1		0.1613***	0.0425***	0.2038***	0.7771***	-3.5028***	9.3538***		

The table reports the characteristics across the four credit ratings-sorted portfolios. The column *Net Lev.* reports the difference between the leverage ratio and the cash-to-assets ratio. The column *Cash* reports the cash-to-assets ratio defined as the value of corporate cash holdings (item CHE) over the value of the firm's total assets (item AT). The column *Leverage* reports the leverage ratio defined as the sum of long-term debt (item DLTT) and debt in current liabilities (item DLC) over the value of the firm's total assets (item AT). The column *Book-to-Market* reports the book-to-market ratio. Following Chen, Novy-Marx, and Zhang (2011), the book value is equal to the book value of shareholder equity, plus balance sheet deferred taxes and investment tax credits (item TXDITC, if available), minus the book value of preferred stock. Shareholder equity is measured using stockholder equity (item SEQ). If the variable is not available, I use common equity (item CEQ) plus the carrying value of preferred stock (item PSTK). If both shareholder equity and common equity are missing, I use total assets (item AT) minus total liabilities (item LT). The book value of preferred stock is measured using the redemption value (item PSTKR, if available). If the quantity is missing, I use the liquidation value (item PSTKL, if available). The book-to-market ratio (*BM*) is equal to the book value of equity by the market value of equity at portfolio formation. The column *Size* reports the market value of equity at portfolio formation. The column *Rating I* reports the numerical value of the variable S&P Domestic Long Term Issuer Credit Rating (item SPLTICRM). The column *Rating II* reports percentage of observations with non-investment grade credit rating. The last column reports the number of stocks in each portfolio. All of the reported values are time-series averages of cross-sectional means. The last row reports the difference in average characteristics between the top decile and the bottom decile. Portfolios are rebalanced annually at the beginning of June over the time period 1986-2010. The 1%, 5%, and 10% significance levels are denoted with ***, **, and *, respectively.

Table 11: Credit ratings sorted portfolios: raw and risk-adjusted returns

Portfolio	Simple		Risk-Adjusted I		Risk-Adjusted II	
	EW (1)	VW (2)	EW (3)	VW (4)	EW (5)	VW (6)
1	0.7673	0.7485	0.2174	0.2083	0.2191	0.2053
2	0.7864	0.7673	0.1311	0.1185	0.1965	0.1777
3	0.8358	0.7982	0.0963	0.0649	0.2699	0.2171
4	0.4848	0.4305	-0.1551	-0.2103	0.1468	0.049
4-1	-0.2825	-0.3180	-0.3725***	-0.4186***	-0.0723	-0.1563

This table reports the raw and risk-adjusted returns for the four credit ratings-sorted portfolios. Columns 1 and 2 report the average realized equity returns in excess of the risk-free rate for the equally weighted and value weighted portfolios, respectively. Columns 3 and 4 report the risk-adjusted equity returns generated by the Carhart four-factor model for the equally weighted and value weighted portfolios, respectively. The reported risk-adjusted equity return for portfolios $i = 1, \dots, 10$ is the intercept of the monthly time-series linear regression below:

$$r_t^i - r_t^f = \alpha + \beta_{MKT}(MKT_t - r_t^f) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \beta_{MOM}MOM_t + \varepsilon_t^i.$$

Columns 5 and 6 report the risk-adjusted equity returns generated by the Carhart four-factor model augmented with the net leverage based factor for the equally weighted and value weighted portfolios, respectively. In this case, the reported risk-adjusted equity return for portfolios $i = 1, \dots, 10$ is the intercept of the monthly time-series linear regression below:

$$r_t^i - r_t^f = \alpha + \beta_{MKT}(MKT_t - r_t^f) + \beta_{SMB}SMB_t + \beta_{HML}HML_t + \beta_{MOM}MOM_t + \beta_{LNMHN}LNMHN_t + \varepsilon_t^i.$$

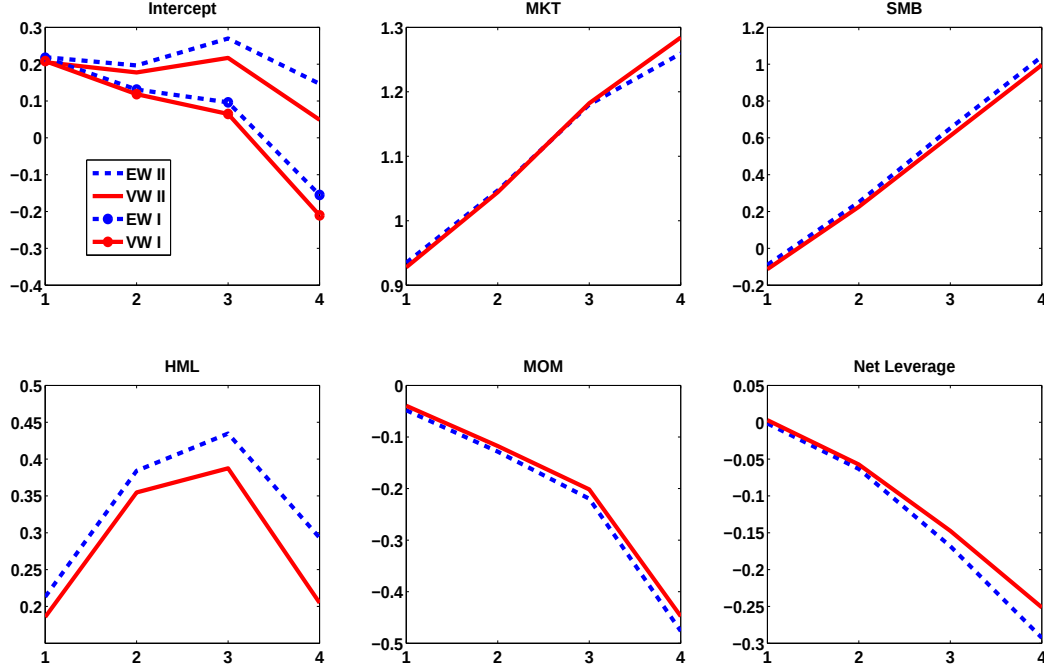
The last row reports the difference in raw and risk-adjusted equity returns between the top and bottom portfolios. Portfolios are rebalanced annually at the beginning of June over the time period 1986-2010. The 1%, 5%, and 10% significance levels are denoted with ***, **, and *, respectively. The t-statistics are evaluated following Newey and West (1987) and using 12 lags.

vulnerable repayment capacity (B+ to B-) in the last (highest credit risk) portfolio. High credit risk firms are relatively small value firms with a significantly higher leverage and cash-to-assets ratio. Unlike in the net leverage sorted portfolios, the cash-to-assets ratio does not show a monotone behavior across the four credit categories but a U-shaped relation similar to that documented in Acharya, Davydenko, and Strebulaev (2011).

Table 11 reports the raw and risk-adjusted returns for the four portfolios. Even if its value is negative, the differential in raw returns between the high credit risk portfolio and the low credit risk portfolio is not statistically significant. On the other hand, when returns are adjusted with the Carhart four-factor model (columns 3 and 4), risk-adjusted returns are monotonically decreasing in credit ratings and the differences in risk-adjusted returns between the top and bottom portfolios are negative and statistically significant for both equally weighted and value weighted portfolios. These results are comparable with the risk-adjusted returns pattern documented by Avramov, Chordia, Jostova, and Philipov (2012, Table 1), even though they do not include the Momentum factor as an explanatory variable.

When the Carhart four-factor model is augmented with the net leverage based factor (columns 5 and 6), the risk-adjusted return differential becomes smaller in absolute value and is not statistically different from zero. The risk-adjusted returns (intercept) and the factor loadings for the Carhart four-factor model and the Carhart four-factor model augmented with the net leverage-based factor are depicted in Figure 7. All the factor loadings have a monotone behavior across the four portfolios except the HML factor. Unlike in the net leverage sorted portfolios, the net leverage based factor is not the only driver of the negative spread between the top and the bottom portfolios because the loadings on the momentum factor (MOM) are also decreasing in credit risk. The loading on the Momentum factor for the bottom portfolio is -0.05 (-0.04) in the equally weighted case (value weighted case) with a standard deviation of 0.04 (0.04), while the loading on the top portfolio is -0.48 (-0.45) with a standard deviation of 0.06 (0.05). It follows that the Momentum factor generates negative differential between the top and the bottom portfolios in the equally weighted (value weighted) case equal to $-0.43 \times 0.73\% = -0.31\%$ ($-0.41 \times 0.73\% = -0.30\%$) per month. On the other hand, the loading on the net leveraged based factor for the bottom portfolio is 0.00 (0.00) in the equally weighted (value weighted) case with a standard deviation of 0.07 (0.06), while the loading on the top portfolio is -0.30 (-0.25) with a standard deviation of 0.08 (0.07). It follows that the net leverage factor generates a negative differential between the top and the bottom in the

Figure 7: Credit Rating Sorted Portfolios: Factor Loadings



This figure depicts the intercept and the factor loadings relative to the regressions reported in Table 11. The top left panel reports the risk-adjusted returns generated by the Carhart four-factor model for the equally weighted and value weighted case (lines *EWI* and *VWI*, respectively) and the augmented Carhart four-factor model for the equally weighted and value weighted case (lines *EWII* and *VWII*, respectively). The reported factor loadings for the equally weighted (dotted blue line) and value weighted (solid red line) cases are generated using the augmented Carhart four-factor model. The ones generated using the Carhart four-factor model look almost identical and are not reported.

equally weighted (value weighted) case equal to $-0.30 \times 1.00\% = -0.30\%$ ($-0.25 \times 1.00\% = -0.25\%$) per month.

Overall, the data show support for the negative relation between credit spreads (proxied using a firm's credit rating) and equity returns. I also document that this negative relation is driven by the Momentum and the net leverage factor, thus providing an explanation to the credit risk puzzle which is incremental to the mispricing effect discussed in Avramov, Chordia, Jostova, and Philipov (2009).

4. Conclusion

This paper studies a model that delivers a negative relation between net leverage (and credit spreads) and expected equity returns. The result is driven by the fact that high-risk firms (i.e., firms whose cash flows are more correlated with an aggregate shock) have higher expected financing cost. For this reason, they optimally choose a lower level of net leverage to minimize future external

financing costs that can be related to equity issuance or debt restructuring. At the same time, the lower expected financing cost of less risky firms induces them to issue more debt to exploit the tax advantage of debt and to accept a higher probability of default. This mechanism provides a risk-based explanation to the credit risk puzzle which is alternative to the mispricing effect discussed in Avramov, Chordia, Jostova, and Philipov (2009).

The empirical part supports the model's predictions. When I adjust returns for characteristics known to affect them, low net leverage firms earn on average an excess return of 0.47% per month over high net leverage firms. This excess return is very highly correlated with the excess returns of investment strategies based on cash holdings and book leverage, thus providing evidence that cash can be considered as negative debt for investment purposes. When I perform a portfolio analysis in the tradition of Fama and French (1992), firms in the bottom net leverage portfolio earn a positive and significant risk-adjusted return over firms in the top net leverage portfolio (1.08% and 0.75% per month for the equally weighted and value weighted portfolios, respectively). The result survives when I restrict the analysis to firms with a credit rating. I also show that the negative relation between credit ratings—my proxy for credit spreads—and equity returns that emerges in the data (the credit risk puzzle) disappears when I add a net leverage-based factor to the Carhart four-factor model.

References

- Acharya, V. V., Davydenko, S. A., Strebulaev, I. A., 2011. Cash holdings and credit spreads. Unpublished working paper 16995, National Bureau of Economic Research, Cambridge, MA.
- Avramov, D., Chordia, T., Jostova, G., Philipov, A., 2009. Credit ratings and the cross-section of stock returns. *Journal of Financial Markets* 12 (3), 469–499.
- Avramov, D., Chordia, T., Jostova, G., Philipov, A., 2012. Anomalies and financial distress. *Journal of Financial Economics*, forthcoming.
- Bagnoli, M., Bergstrom, T., 2005. Log-concave probability and its applications. *Economic Theory* 26 (2), 445–469.
- Barlow, R. E., Marshall, A. W., Proschan, F., 1963. Properties of probability distributions with monotone hazard rate. *The Annals of Mathematical Statistics* 34 (2), 375–389.

- Berk, J. B., Green, R. C., Naik, V., 1999. Optimal investment, growth options, and security returns. *Journal of Finance* 54 (5), 1553–1607.
- Bhamra, H. S., Kuehn, L.-A., Strebulaev, I. A., 2010. The levered equity risk premium and credit spreads: A unified framework. *Review of Financial Studies* 23 (2), 645–703.
- Bhandari, L. C., 1988. Debt–equity ratio and expected common stock returns: Empirical evidence. *Journal of Finance* 43 (2), 507–528.
- Carhart, M. M., 1997. On persistence in mutual fund performance. *Journal of Finance* 52 (1), 57–82.
- Chen, L., Novy-Marx, R., Zhang, L., 2011. An alternative three-factor model. Unpublished working paper. Social Science Research Network eLibrary, <http://ssrn.com/paper=1418117>.
- Dichev, I. D., 1998. Is the risk of bankruptcy a systematic risk? *Journal of Finance* 53 (3), 1131–1147.
- Fama, E. F., 1976. *Foundations of Finance*. Basic Books.
- Fama, E. F., French, K. R., 1992. The cross-section of expected stock returns. *Journal of Finance* 47 (2), 427–465.
- Fama, E. F., French, K. R., 1993. Common risk factors in the returns on stocks and bonds. *Journal of Finance* 33 (1), 3–56.
- Fama, E. F., French, K. R., 2008. Dissecting anomalies. *Journal of Finance* 63 (4), 1653–1678.
- Fama, E. F., MacBeth, J. D., 1973. Risk, return, and equilibrium: Empirical tests. *Journal of Political Economy* 81, 607–636.
- Garlappi, L., Yan, H., 2011. Financial distress and the cross-section of equity returns. *Journal of Finance* 66 (3), 789–822.
- George, T. J., Hwang, C. Y., 2004. The 52-week high and momentum investing. *Journal of Finance* 69 (5), 2145–2176.
- George, T. J., Hwang, C. Y., 2010. A resolution of the distress risk and leverage puzzles in the cross section of stock returns. *Journal of Financial Economics* 96, 56–79.

- Glover, B., 2011. The expected cost of default. Working Paper.
- Gomes, J. F., Schmid, L., 2010. Levered returns. *Journal of Finance* 65 (2), 467–494.
- Griffin, J. M., Lemmon, M. L., 2002. Book-to-market equity, distress risk, and stock returns. *Journal of Finance* 57 (5), 2317–2336.
- Kuehn, L.-A., Schmid, L., 2012. Investment-based corporate bond pricing. Unpublished working paper.
- Leland, H. E., 1994. Corporate debt value, bond covenants, and optimal capital structure. *Journal of Finance* 49 (4), 1213–1252.
- Li, E. X., 2009. Does corporate governance affect the cost of equity capital? Working Paper, Ross School of Business, University of Michigan.
- Merton, R. C., 1974. On the pricing of corporate debt: The risk structure of interest rates. *Journal of Finance* 29 (2), 449–470.
- Newey, W. K., West, K. D., 1987. A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix. *Econometrica* 55 (3), 703–708.
- Ozdagli, A. K., 2012. Financial leverage, corporate investment, and stock returns. *Review of Financial Studies* 25 (4), 1033–1069.
- Palazzo, B., 2012. Cash holdings, risk, and expected returns. *Journal of Financial Economics*, forthcoming.
- Penman, S. H., Richardson, S. A., Tuna, I., 2007. The book-to-price effect in stock returns: Accounting for leverage. *Journal of Accounting Research* 45 (2), 427–467.
- Shumway, T., 1997. The delisting bias in CRSP data. *Journal of Finance* 52 (1), 327–340.
- Simutin, M., 2010. Excess cash and stock returns. *Financial Management* 39 (3), 1197–1222.
- Zhang, L., 2005. The value premium. *Journal of Finance* 60 (1), 67–103.

Appendix A

In this appendix, I provide proofs for the results discussed in Section 2.

A.1. Continuation value for the firm's problem

Note that it is never optimal for the firm to issue debt and save the proceeds because the internal accumulation rate is lower than the risk-free rate (i.e. cash is negative debt). For this reason, we can use net leverage as the unique choice variable and the problem of the firm becomes

$$V(W_0) \equiv \max \left\{ 0, \max_{N_1} (1 + \lambda \mathbf{1}_{[D_0 \leq 0]}) D_0 + E_0[M_1 V_1] \right\}, \quad (25)$$

subject to the constraints described in Equations 8, 9, and 10. To derive the continuation value $E_0[M_1 V_1]$, I rely on Result A.1.

Result A.1. *Let M_1 be the SDF defined in footnote 4, x_1 the stochastic process for the cash flow also defined in footnote 4, and A and B any two variables whose values are known at time 0. Then*

$$\begin{aligned} E_0[M_1(A + Be^{x_1}) | \underline{x} \leq x_1 \leq \bar{x}] &= Ae^{-r} \left(\frac{\Phi\left(\varepsilon_{\bar{x}} + \frac{\beta_{xm}}{\sigma_x}\right) - \Phi\left(\varepsilon_{\underline{x}} + \frac{\beta_{xm}}{\sigma_x}\right)}{Pr(\bar{x} \leq x_1 \leq \underline{x})} \right) \\ &\quad + Be^{-r} e^{\mu - \beta_{xm}} \left(\frac{\Phi\left(\varepsilon_{\bar{x}} + \frac{\beta_{xm}}{\sigma_x} - \sigma_x\right) - \Phi\left(\varepsilon_{\underline{x}} + \frac{\beta_{xm}}{\sigma_x} - \sigma_x\right)}{Pr(\bar{x} \leq x_1 \leq \underline{x})} \right), \end{aligned} \quad (26)$$

where Φ is the cumulative distribution function of a standard normal variable, $\varepsilon_{\bar{x}}$ is equal to $\frac{\bar{x} - \mu + 0.5\sigma_x^2}{\sigma_x}$, and $\varepsilon_{\underline{x}}$ is equal to $\frac{\underline{x} - \mu + 0.5\sigma_x^2}{\sigma_x}$.

The continuation value $E_0[M_1 V_1]$ when $\pi = 1$ can be explicitly rewritten as

$$\begin{aligned} E_0[M_1 V_1] &= E_0 \left[M_1 \left((1 + \lambda)((1 - \tau)e^{x_1} - N_1 - 1) + R^{-1}C_2 \right) | \kappa_{di} \leq x_1 \leq \kappa_i \right] Pr(\kappa_{di} \leq x_1 \leq \kappa_i) \\ &\quad + E_0 \left[M_1 \left((1 - \tau)e^{x_1} - N_1 - 1 + R^{-1}C_2 \right) | x_1 \geq \kappa_i \right] Pr(x_1 \geq \kappa_i). \end{aligned} \quad (27)$$

By virtue of Result A.1., the continuation value takes the following form

$$E_0[M_1 V_1] = e^{-r} \left[(1 - \tau)e^{\mu - \beta_{xm}} \left(1 + \lambda\Phi_3 - (1 + \lambda)\Phi_1 \right) + (-N_1 - 1) \left(1 + \lambda\Phi_4 - (1 + \lambda)\Phi_2 \right) + e^{-r}C_2(1 - \Phi_2) \right], \quad (28)$$

where $\varepsilon_{di} = \frac{\kappa_{di} - \mu + 0.5\sigma_x^2}{\sigma_x}$, $\varepsilon_i = \frac{\kappa_i - \mu + 0.5\sigma_x^2}{\sigma_x}$, $\varepsilon_{dn} = \frac{\kappa_{dn} - \mu + 0.5\sigma_x^2}{\sigma_x}$ and

$$\Phi_1 = \Phi\left(\varepsilon_{di} + \frac{\beta_{xm}}{\sigma_x} - \sigma_x\right); \Phi_2 = \Phi\left(\varepsilon_{di} + \frac{\beta_{xm}}{\sigma_x}\right); \Phi_3 = \Phi\left(\varepsilon_i + \frac{\beta_{xm}}{\sigma_x} - \sigma_x\right); \Phi_4 = \Phi\left(\varepsilon_i + \frac{\beta_{xm}}{\sigma_x}\right).$$

The quantities κ_{di} , κ_i , and κ_{dn} are defined in Section 2.2.1. The continuation value for the risk-free debt case can be derived setting $\Phi_1 = \Phi_2 = 0$ in Equation (45).

A.2. The risk-free case: The Euler equation and optimal net leverage policy

The firm's problem in the risk-free case satisfies the first order condition below¹⁸

$$\frac{1 + \lambda \mathbf{1}_{[D_0 \leq 0]}}{\hat{R}} = \frac{1 + \lambda \Phi_4}{R}. \quad (30)$$

When time 0 net worth is positive, then the Euler equation is

$$\frac{1}{\hat{R}} \geq \frac{1 + \lambda \Phi_4}{R}. \quad (31)$$

In this case, the firm chooses N_1 over the interval $[-W_0, \overline{L}_1]$. Notice that the RHS is smaller than the LHS when $N_1 = -1$ (in such a case $\Phi_4 = 0$) and it is also strictly increasing in N_1 . It follows that an interior solution is always unique. Firms with an RHS value smaller than $1/\hat{R}$ when $N_1 = \overline{L}_1$ optimally choose to borrow up to their debt limit so that optimal leverage equals $\overline{L}_1$. On the other hand, firms with an RHS value larger than $1/\hat{R}$ when $N_1 = \overline{L}_1$ optimally choose a net leverage value in $(-1, \overline{L}_1)$. Notice that firms that have an unconstrained optimal value of net leverage smaller than $-W_0$ optimally choose $N_1 = -W_0$ because it is not optimal to raise external financing and save the proceeds.

¹⁸ Consider the following result:

$$\frac{d\Phi(f(x) - \sigma_x)}{dx} = \phi(f(x) - \sigma_x) f_x(x) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(f(x) - \sigma_x)^2}{2}} f_x(x) = \phi(f(x)) e^{f(x)\sigma_x - \frac{\sigma_x^2}{2}} f_x(x),$$

where ϕ is the probability distribution of a standard normal variable. If we set $f(x) = \varepsilon_i + \frac{\beta_{xm}}{\sigma_x}$, then

$$(1 - \tau) e^{\mu - \beta_{xm}} \frac{\partial \Phi_3}{\partial N_1} = \frac{1 - \tau}{\sigma_x} \phi\left(\varepsilon_i + \frac{\beta_{xm}}{\sigma_x}\right) = (N_1 + 1) \frac{\partial \Phi_4}{\partial N_1}.$$

This allows us to simplify the first-order condition in Equation (29):

$$\frac{1 + \lambda \mathbf{1}_{[D_0 \leq 0]}}{\hat{R}} + e^{-r} \left[(1 - \tau) e^{\mu - \beta_{xm}} \lambda \frac{\partial \Phi_3}{\partial N_1} - (1 + \lambda \Phi_4) - (N_1 + 1) \lambda \frac{\partial \Phi_4}{\partial N_1} \right] = 0. \quad (29)$$

When time 0 net worth is negative ($W_0 < 0$), then the Euler equation is

$$\begin{cases} \frac{1+\lambda}{\hat{R}} > \frac{1+\lambda\Phi_4}{R} & \text{if } D_0 < 0 \\ \frac{1}{\hat{R}} > \frac{1+\lambda\Phi_4}{R} & \text{otherwise} \end{cases}. \quad (32)$$

If liabilities do not exceed the debt limit, then it is optimal to repay them by issuing debt. In this case, firms with an RHS value larger than $1/\hat{R}$ when $N_1 = -W_0$ optimally choose not to borrow any additional amount, while firms with an RHS value smaller than $1/\hat{R}$ when $N_1 = \overline{L}_1$ optimally choose to borrow up to their debt limit. To conclude, firms with an RHS value smaller than $1/\hat{R}$ when $N_1 = -W_0$ and an RHS value larger than $1/\hat{R}$ when $N_1 = \overline{L}_1$, choose an optimal leverage in the interval $-W_0, \overline{L}_1$. If liabilities exceed $\overline{L}_1$, firms will always issue debt up to $\overline{L}_1$ and then issue equity to repay the remaining amount.

When an interior solution exists, the optimal net leverage policy is increasing in the mean of the cash flow process μ , decreasing in the cost of external financing λ , and decreasing in the firm's riskiness $\beta_{x,m}$. These properties can be derived taking the total differential implied by the Euler equation with respect to N_1 and the relevant parameters.

A.3. The bond pricing equation and credit spread: Properties

The bond pricing equation can be rewritten as

$$B_1 = N_1 \left(\hat{R} + s_1(N_1) \right)^{-1}, \quad (33)$$

where

$$s_1(N_1) = (1 - \tau)R \left(\frac{\Phi_2}{1 - \Phi_2} \right) \quad (34)$$

is the firm's credit spread. The credit spread in Equation (34) is strictly increasing in N_1 , strictly increasing in β_{xm} , and strictly decreasing in μ ¹⁹.

If the credit spread is a convex function, then B_1 has a unique interior maximum, B_1^{max} . I first provide a condition that ensures a convex credit spread, namely a credit spread value increasing at

$$\frac{^{19} \frac{ds_1(N_1)}{dN_1}}{dN_1} = (1 - \tau)R \left[\frac{\Phi'_2(\sigma_x(N_1 - \overline{L}_1))^{-1}}{(1 - \Phi_2)^2} \right] > 0, \frac{ds_1(N_1)}{d\beta_{xm}} = (1 - \tau)R \left[\frac{\Phi'_2(\sigma_x)^{-1}}{(1 - \Phi_2)^2} \right] > 0, \text{ and } \frac{ds_1(N_1)}{d\mu} = (1 - \tau)R \left[\frac{-\Phi'_2(\sigma_x)^{-1}}{(1 - \Phi_2)^2} \right] < 0.$$

an increasing rate. The second derivative of the credit spread is

$$\frac{ds_1(N_1)}{dN_1 dN_1} = (1 - \tau)R \left(\frac{\Phi'_2(\sigma_x(N_1 - \overline{L}_1))^{-2}}{(1 - \Phi_2)^2} \right) \left(-\sigma_x + \frac{\Phi''_2}{\Phi'_2} + \frac{2\Phi'_2}{1 - \Phi_2} \right), \quad (35)$$

and the credit spread is convex if the following condition is satisfied:

$$\frac{\Phi'_2}{1 - \Phi_2} > \frac{1}{2} \left(\sigma_x - \frac{\Phi''_2}{\Phi'_2} \right) \Rightarrow h(y) > \frac{1}{2} (\sigma_x + y), \quad (36)$$

where $y = \varepsilon_{di} + \frac{\beta_{xm}}{\sigma_x}$ and $h(x)$ is the strictly increasing hazard rate of a standard normal distribution (see Barlow, Marshall, and Proschan (1963) and Bagnoli and Bergstrom (2005), among others). Then a sufficient condition for a (globally) convex credit spread is to have $\sigma_x < 2(h(y^*) - 0.5y^*) = 1.5176$, where y^* is such that $h'(y^*) = 0.5$.

Now I can show that if the credit spread is convex in N_1 , then the bond pricing equation has a unique maximum. The first-order condition for the bond pricing equation is

$$\frac{dB_1}{dN_1} = \frac{B_1}{N_1} \left(1 - B_1 \frac{ds_1(N_1)}{dN_1} \right), \quad (37)$$

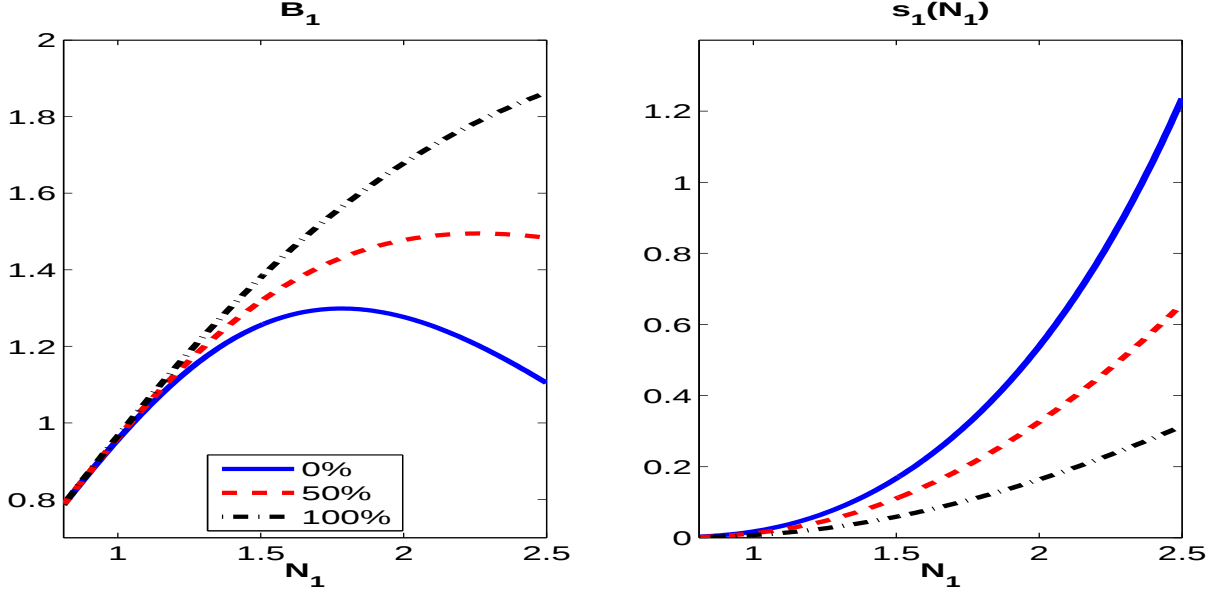
and a maximum satisfies

$$B_1^{-1} = \frac{ds_1(N_1)}{dN_1} \Rightarrow \hat{R} + s_1(N_1) = N_1 \frac{ds_1(N_1)}{dN_1}. \quad (38)$$

For N_1 that converges to $\overline{L}_1$, the term $\hat{R} + s_1(N_1)$ converges to $\hat{R}$, while $N_1 \frac{ds_1(N_1)}{dN_1}$ goes to zero. On the other hand, if N_1 goes to infinity then both terms also go to infinity. It follows that there is only one value satisfying Equation (38) because $N_1 \frac{ds_1(N_1)}{dN_1}$ grows faster than $\hat{R} + s_1(N_1)$ ²⁰. Figure 8 depicts the bond pricing equations for different values of the recovery rate (left panel). Notice that the value of B_1^{max} is increasing in the recovery rate, while the credit spread (right panel) is decreasing in the recovery rate.

²⁰The first derivative of $\hat{R} + s_1(N_1)$ is $\frac{ds_1(N_1)}{dN_1}$, while the first derivative of $N_1 \frac{ds_1(N_1)}{dN_1}$ is $\frac{ds_1(N_1)}{dN_1} + N_1 \frac{d^2s_1(N_1)}{dN_1^2}$, which is larger for each value of $N_1 > \overline{L}_1$ given the convexity of the credit spread. An alternative argument is the following. Let us assume that there is more than one maximum. It follows that there must be two values of N_1 , N_1^a and N_1^b with $\overline{L}_1 < N_1^a < N_1^b$, such that $B_1(N_1^a) = B_1(N_1^b) = \overline{B}$ and $B_1(N_1) < \overline{B}$ for all $N_1 \in (N_1^a, N_1^b)$. In the interval (N_1^a, N_1^b) , B_1 is first decreasing and then increasing in N_1 ; it follows that the credit spread N_1/B_1 is not increasing at an increasing rate over (N_1^a, N_1^b) . This violates the convexity of the credit spread function.

Figure 8: Debt Pricing Equation



The left panel depicts the debt pricing equation in (8), while the right panel depicts the credit spread as a function of N_1 for three different values of the recovery rate upon default ξ : 0% (solid blue line), 50% (dashed red line), and 100% (dashed-dotted black line). The parameter values are $W_0 = 1$, $R = 1.04$, $\tau = 0.30$, $\lambda = 0.10$, $\sigma_x = 0.5$, $\sigma_z = 0.4$, and $C_2 = 1.5$ and $\mu = 1.2$.

A.4. The risky case: The Euler equation and optimal net leverage policy

An interior solution for the firm problem in the risky case satisfies the first-order condition below:

$$\begin{aligned} (1 + \lambda \mathbf{1}_{[D_0 \leq 0]}) \frac{dB_1}{dN_1} + e^{-r} \left[(1 - \tau) e^{\mu - \beta_{xm}} \left(\lambda \frac{\partial \Phi_3}{\partial N_1} - (1 + \lambda) \frac{\partial \Phi_1}{\partial N_1} \right) - (1 + \lambda \Phi_4 - (1 + \lambda) \Phi_2) \right. \\ \left. + (-N_1 - 1) \left(\lambda \frac{\partial \Phi_4}{\partial N_1} - (1 + \lambda) \frac{\partial \Phi_2}{\partial N_1} \right) - \frac{\partial \Phi_2}{\partial N_1} e^{-r} C_2 \right] = 0. \end{aligned}$$

Given that Φ_2 matters only if N_1 exceeds the risk-free debt limit $\overline{L}_1$, we can rewrite the Euler equation as

$$(1 + \lambda \mathbf{1}_{[D_0 \leq 0]}) \frac{dB_1}{dN_1} = e^{-r} \left[1 + \lambda \Phi_4 + \mathbf{1}_{[N_1 \geq \overline{L}_1]} \left(\frac{\Phi'_2 e^{-r} C_2}{\sigma_x (N_1 - \overline{L}_1)} - (1 + \lambda) \Phi_2 \right) \right]. \quad (39)$$

I have already illustrated that the optimal net leverage is decreasing in the firm's riskiness when $N_1 \leq \overline{L}_1$, so I only need to check if the total differential of N_1 w.r.t. β_{xm} is negative using the following version of the Euler equation for values of N_1 larger than $\overline{L}_1$. The LHS in Equation (39) is the marginal benefit of issuing debt, which equals the sum of the marginal increase in time 0 dividend distribution (or the marginal decrease in time 0 equity issuance costs if the firm has negative net worth) and the benefit of defaulting given by the missed time 1 repayment. The RHS is the marginal cost of issuing debt, which equals the time 1 debt repayment and the corresponding

marginal increase in the probability of being financially constrained plus the cost related to the possibility of foregoing a time 1 growth option with positive net present value.

If the LHS is decreasing in β_{xm} and the RHS is increasing in β_{xm} , then an increase in the firm's riskiness causes a downward shift of the marginal benefit curve and an upward shift of the marginal cost curve. The result is a lower optimal net leverage value. This is the same as having the below term decreasing in β_{xm} :

$$(1 + \lambda \mathbf{1}_{[D_0 \leq 0]}) \frac{dB_1}{dN_1} + e^{-r} \left[1 + \lambda(\Phi_2 - \Phi_4) + \Phi_2 - \frac{\Phi'_2 e^{-r} C_2}{\sigma_x(N_1 - \overline{L}_1)} \right]. \quad (40)$$

Let us assume that the optimal default probability is low, so that both Φ_4 and Φ_2 are less than 0.50. Because of the convexity of credit spreads, $\frac{dB_1}{dN_1}$ is decreasing in the cash flow riskiness; in addition, also $\lambda(\Phi_2 - \Phi_4)$ is decreasing in β_{xm} because if Φ_4 and Φ_2 are less than 0.50, then $\varepsilon_i > \varepsilon_{di}$ implies $\Phi'_4 > \Phi'_2$. If the quantity $\Phi_2 - \frac{\Phi'_2 e^{-r} C_2}{\sigma_x(N_1 - \overline{L}_1)}$ is also decreasing in β_{xm} , then the optimal net leverage is decreasing in the firm's riskiness also when $N_1 > \overline{L}_1$. The derivative of the latter quantity w.r.t. β_{xm} is negative if the following condition is satisfied:

$$\frac{\sigma_x(N_1 - \overline{L}_1)}{e^{-r} C_2} < \frac{\Phi''_2}{\Phi'_2} = - \left(\varepsilon_{di} + \frac{\beta_{xm}}{\sigma_x} \right). \quad (41)$$

Note that for N_1 that goes to $\overline{L}_1$, the LHS of Equation (41) converges to zero, while the RHS goes to $+\infty$. It follows that for small values of N_1 (i.e. $N_1 \rightarrow \overline{L}_1$), the optimal net leverage is decreasing in the firm's riskiness. Figure 9 shows that the negative relation between optimal net leverage and risk is robust across different parameter values.

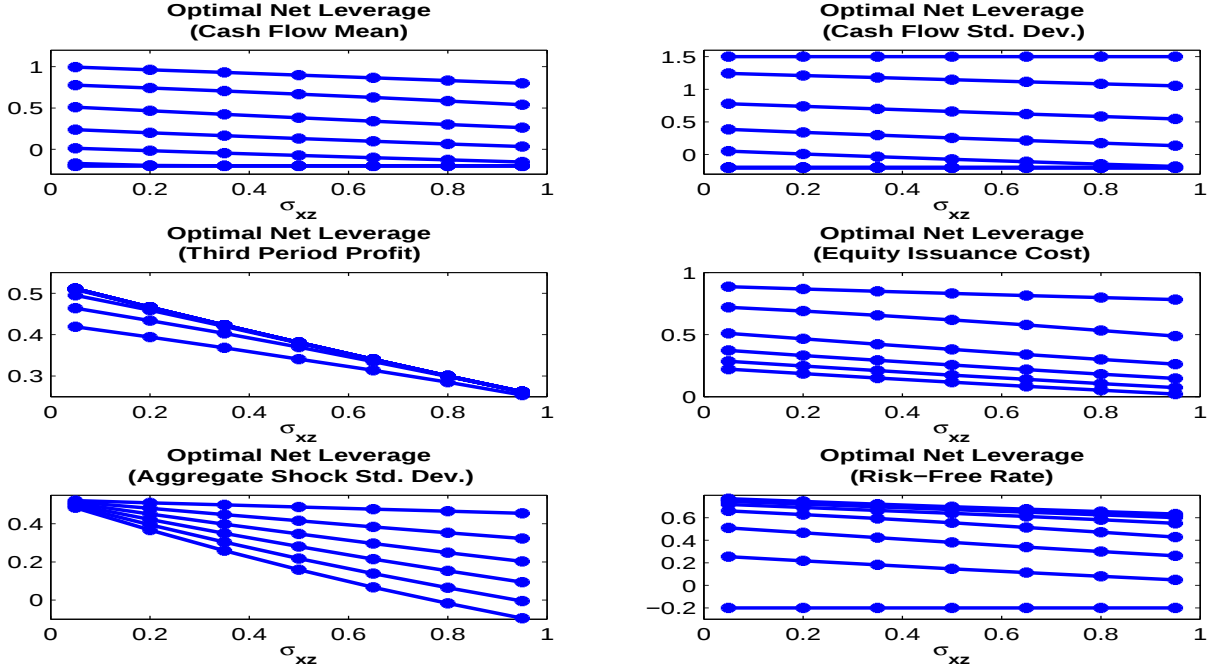
A.5. The risky case: Credit spreads and equity returns

The expected equity return in Equation (22) can be rewritten as $f(\sigma_{xz})/g(\sigma_{xz})$, so the first-order condition w.r.t. σ_{xz} is

$$\frac{E_0[R_{0,1}]}{d\sigma_{xz}} = \frac{f'(\sigma_{xz})g(\sigma_{xz}) - f(\sigma_{xz})g'(\sigma_{xz})}{g^2(\sigma_{xz})}. \quad (42)$$

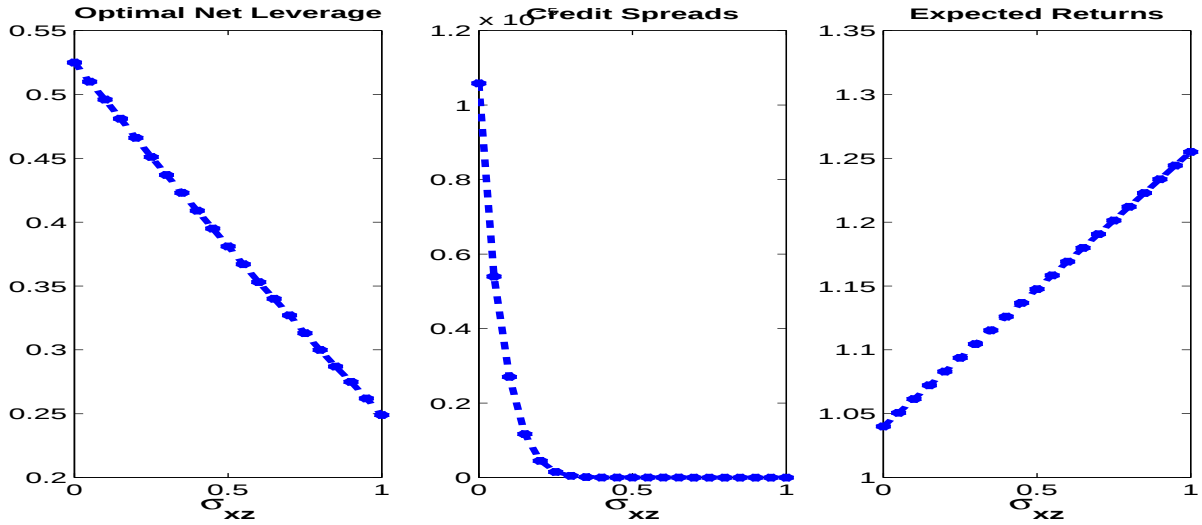
Equation (42) is positive if we assume a time 0 ex-dividend value of the firm decreasing in cash flow riskiness (i.e., $g'(\sigma_{xz}) < 0$). This assumption is sufficient to generate expected equity returns increasing in σ_{xz} because $f(\sigma_{xz})$ is also increasing in σ_{xz} .

Figure 9: Sensitivity Analysis



This figure depicts the optimal net leverage as a function of the firm's riskiness σ_{xz} for different values of the parameters μ , σ_x , C_2 , λ , σ_z , and R . In the top left panel, μ varies from 0.5 to 2. In the top right panel, σ_x varies from 0.1 to 1.5. In the central left panel, C_2 varies from 1.144 to 2.5. In the central right panel, λ varies from 0.02 to 0.24. In the bottom left panel, σ_z varies from 0.1 to 1.2. In the bottom right panel, R varies from 1 to 1.15. The baseline case parameter values are $\mu = 1.5$, $\sigma_x = 0.5$, $C_2 = 1.5$, $\lambda = 0.10$, $\sigma_z = 0.4$, $\tau = 0.30$, and $R = 1.04$.

Figure 10: Optimal Net Leverage, Credit Spreads, and Expected Returns



This figure depicts the optimal net leverage policy (left panel), the credit spreads (central panel), and the expected equity returns (right panel) as a function of the firm's riskiness. The parameter values are $\mu = 1.5$, $\sigma_x = 0.5$, $C_2 = 1.5$, $\lambda = 0.10$, $\sigma_z = 0.4$, $\tau = 0.30$, and $R = 1.04$.

The expected value of future dividends at time 0 is

$$\begin{aligned} E_0[V_1] &= E_0 \left[(1 + \lambda)((1 - \tau)e^{x_1} - N_1 - 1) + R^{-1}C_2 | \kappa_{di} \leq x_1 \leq \kappa_i \right] Pr(\kappa_{di} \leq x_1 \leq \kappa_i) \\ &\quad + E_0 \left[(1 - \tau)e^{x_1} - N_1 - 1 + R^{-1}C_2 | x_1 \geq \kappa_i \right] Pr(x_1 \geq \kappa_i). \end{aligned} \quad (43)$$

Using Result A.1., Equation (43) can be rewritten as

$$E_0[V_1] = \left[(1 - \tau)e^\mu \left(1 + \lambda \hat{\Phi}_3 - (1 + \lambda) \hat{\Phi}_1 \right) + (-N_1 - 1) \left(1 + \lambda \hat{\Phi}_4 - (1 + \lambda) \hat{\Phi}_2 \right) + e^{-r} C_2 \left(1 - \hat{\Phi}_2 \right) \right] \quad (44)$$

where

$$\hat{\Phi}_1 = \Phi(\varepsilon_{di} - \sigma_x); \quad \hat{\Phi}_2 = \Phi(\varepsilon_{di}); \quad \hat{\Phi}_3 = \Phi(\varepsilon_i - \sigma_x); \quad \hat{\Phi}_4 = \Phi(\varepsilon_i).$$

Using the same argument described in footnote 18, I can write the derivative of $E_0[V_1]$ w.r.t. σ_{xz} as

$$\frac{dE_0[V_1]}{d\sigma_{xz}} = -\frac{dN_1^*}{d\sigma_{xz}} \left[\frac{e^{-r}C_2}{\sigma_x(N_1^* - \overline{L}_1)} + \left(1 + \lambda \hat{\Phi}_4 - (1 + \lambda) \hat{\Phi}_2 \right) \right]. \quad (45)$$

The quantity in the square brackets is positive because $\hat{\Phi}_4 > \hat{\Phi}_2$, while $\frac{dN_1^*}{d\sigma_{xz}}$ is negative because the optimal net leverage is decreasing in cash flow riskiness. It follows that the expected future dividends are increasing in σ_{xz} . In Figure 10, I illustrate how the optimal net leverage, credit spreads, and expected equity returns vary with the firm's riskiness.