The Risk Anomaly Tradeoff of Leverage*

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Abstract

We develop the implications of the risk anomaly—the weak or inverse empirical relationship between the risk and cost of equity—for corporate leverage. The risk anomaly generates a tradeoff: As firms lever up, the overall cost of capital falls as leverage increases equity risk and takes advantage of the anomaly, but as debt becomes riskier the marginal benefit of increasing equity risk declines. We show that there is an interior optimum in which firms with higher asset beta choose lower leverage. Firms with high upside asset beta choose lower leverage as well, a prediction not shared by the traditional tradeoff with financial distress costs. These predictions find support in leverage regressions.

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It is well known that the link between textbook measures of risk and realized returns in the stock market is weak, if not inverted. For example, a dollar invested in a low beta portfolio of U.S. stocks in 1968 grows to $70.50 by 2011, while a dollar in a high beta portfolio grows to just $7.61.[2] The evidence on the anomalously low returns to high-risk stocks begins as early as Black, Jensen, and Scholes (1972), but the results of Ang, Hodrick, Xing, and Yang (2006) renewed attention to this cross-sectional "risk anomaly."

There is now a burgeoning empirical and theoretical literature, briefly reviewed later in this paper, that considers the risk anomaly as evidence of mispricing rather than a misspecification of risk. In this paper, we consider the implications of the risk anomaly for corporate capital structure. As Goldstein and Hackbarth (2014) point out, "there are still many [empirically] plausible settings and assumptions that have not been explored" (p. 536); accordingly, and in the spirit of Stein (1996), we take mispricing explanations for the risk anomaly as sufficiently plausible to consider their implications for corporate capital structure.

A risk anomaly in equity markets leads to a simple tradeoff. The intuition is as follows. Under the anomaly, risk is overvalued in equity securities, but not in debt securities. Ideally, then, to minimize the cost of capital, risk is concentrated in equity. A firm will always want to issue as much riskless debt as it can. This lowers the cost of equity by increasing its risk without any "inefficient" transfer of risk from equity to debt. But, as debt becomes risky, further increases in leverage have a cost. Shifting overvalued risk in equity securities to fairly valued risk in debt securities increases the cost of capital. For firms with high-risk assets, this increase is high even at low levels of leverage. For firms with very low risk assets, this increase remains low until leverage is high. Using the Merton (1974) model to characterize the functional form of debt

[2] See Baker, Bradley, and Taliaferro (2014).

betas and the underlying transfer of risk from equity to debt, we show that there is an interior optimum leverage ratio that is inversely related to asset beta.

Before we test the theory's predictions, a brief reprise of earlier work on the risk anomaly helps to ground the two key assumptions in a risk anomaly tradeoff of leverage. The first is that the link between beta and average returns is flat or inverted *within* the U.S. stock market. The second is that the link between beta and average returns is large and positive *across* the U.S. stock and corporate bond markets. Markets are segmented: unlike lower beta stocks, corporate bonds do not come with similarly high risk-adjusted returns, despite even lower betas.

The theory's central prediction is that leverage is negatively related to asset risk. Empirically, we find that there is indeed a robust negative relationship between leverage and asset beta. The relationship remains strong when controlling for overall asset variance (a crude control for distress risk), using alternative measures of leverage and industry measures of asset beta and overall risk, including various other control variables, or all of the above.

We also test additional predictions of the risk anomaly tradeoff to distinguish it from traditional explanations based in the tradeoff between taxes and financial distress costs or other theories of capital structure that involve risk. For example, Long and Malitz (1985) include systematic asset risk, not just overall risk, in leverage regressions with the traditional tradeoff in mind, and Schwert and Strebulaev (2014) implicate asset beta as a relevant risk measure under dynamic generalizations of the traditional tradeoff. We prove that, under a linear risk anomaly, both "upside" beta and "downside" beta are inversely related to leverage. In fact, theories that point to a nonlinear risk anomaly typically emphasize upside beta. For example, Karceski (2002) argues that the large flows into equity mutual funds following periods of strong market performance create an incentive for investment managers to outperform conditional on high market returns, or to overweight high upside beta. Financial distress costs, on the other hand, emphasize downside risk. Consistent with the risk anomaly prediction, we find that leverage is indeed inversely related to upside asset beta. In some specifications, the upside beta effect is stronger than the downside beta effect. While the results do not rule out the traditional tradeoff theory, given that downside beta still matters, this prediction and its empirical evidence provide distinct support for a risk anomaly tradeoff.

We note that the risk anomaly mechanism may help to explain extremely high and low leverage levels that challenge the standard tradeoff model. For instance, Graham (2000) and others have pointed out that hundreds of profitable firms, with high marginal tax rates, maintain essentially zero leverage. This is often called the low-leverage puzzle. Conversely, a number of other profitable firms maintain high leverage despite no tax benefit. The risk anomaly tradeoff might help to explain these patterns. If low leverage firms have determined that the tax benefit of debt is less than the opportunity cost of transferring risk to lower-cost equity, low leverage may be optimal even in the presence of additional frictions; a minor transaction cost of issuance could drive some firms to zero leverage. Meanwhile, low asset risk firms with no tax benefits of debt still resist equity because of its high risk-adjusted cost at low levels of leverage, and instead use a very large fraction of debt finance.

In addition to providing a novel perspective on leverage that is consistent with certain empirical patterns, the risk anomaly approach has an attractive and unifying conceptual feature. The traditional tradeoff theory, under rational asset pricing, cannot fit both the leverage and asset pricing evidence on the pricing of beta. If beta *is* truly a measure of risk relevant for capital structure, then presumably it would also help to explain the cross section of asset returns, which it does not. Investors, recognizing the associated investment opportunities, would demand higher returns on assets exposed to the systematic risk of fire sales, with high risk-adjusted costs of financial distress. If beta *is not* a measure of risk, as the large literature that follows Fama and French (1992, 1993) has claimed, then asset beta should not be a constraint on leverage, after controlling for total asset risk. The risk anomaly tradeoff provides a simple and consistent explanation for both of these patterns.

Section 1 briefly reviews the risk anomaly, measures it in our data, and confirms that the anomaly within the equity market does not extend across equity and debt markets. Second 2 derives optimal leverage under a risk anomaly. Sectional 3 contains empirical hypotheses and tests. Section 4 concludes.

1. The Risk Anomaly

The risk anomaly tradeoff in leverage rests on a robust empirical pattern in the relationship between risk and return within the stock market that does not extend across the stock and corporate bond markets. Here we review the older and more recent evidence and associated theories; outline the implications of the risk anomaly for WACC; confirm the risk anomaly in our sample; and, show that there is not an integrated anomaly that fits high risk equity, low risk equity, and corporate debt simultaneously.

1.1. Motivating evidence

Over the long run, riskier asset *classes* have earned higher returns in U.S. markets. Small stocks have outperformed large caps, which have outperformed corporate bonds, which have outperformed long-term Treasuries, and so on (Ibbotson Associates (2012)). The relevant pattern for this paper, however, is the evidence that the historical risk-return tradeoff *within* the stock market is flat at best. The Capital Asset Pricing Model (CAPM) predicts that the expected return on a security is proportional to its systematic risk, i.e., beta, but stocks with higher beta have tended to earn lower returns, particularly on a risk-adjusted basis.

The simple linear specification for the risk anomaly that we employ in this paper is

$$r_e = (\beta_e - 1)\gamma + r_f + \beta_e r_p, \tag{1}$$

where r_f is the risk free rate, r_p is the market risk premium, and $\gamma < 0$ measures the size of the anomaly. The risk anomaly is that a stock's "alpha" falls with its beta.

The risk anomaly is present across stock markets and sample periods. Black (1972), Black, Jensen, and Scholes (1972), Haugen and Heins (1975), and Fama and French (1992) all noted the relatively flat relationship between expected returns and beta in the U.S. Subsequently, Falkenstein (1994) and Ang, Hodrick, Ying, and Zhang (2006) have emphasized the magnitude and robustness of the anomaly, extending it to include not only beta risk but idiosyncratic risk. Blitz and van Vliet (2007), Ang et al. (2009), and Baker et al. (2014) confirm its presence within developed markets and Blitz, Pang, and van Vliet (2013) document it in emerging markets.

Several explanations for the anomaly have been suggested. Most simply, investors may have an irrational preference for volatile or skewed investments due to overconfidence, as in Cornell (2008), or lottery preferences, as in Barberis and Huang (2008), Kumar (2009), and Bali, Cakici, and Whitelaw (2011). Other investors may categorize stocks together and neglect to price differences in risk, as in Barberis and Shleifer (2003). Risk neglect may also reflect inexperience, as in Greenwood and Nagel (2009), Malmendier and Nagel (2011), and Chernenko, Hanson, and Sunderam (2016). Leverage-constrained investors who seek maximum returns from beta risk must buy high beta stocks directly as opposed to forming a levered portfolio of low beta stocks (Black (1972) and Frazzini and Pedersen (2014)), thus pushing down the expected returns on high beta stocks.

Sophisticated investors may have trouble competing the anomaly away. Fund managers may prefer high-beta assets themselves because the inflows to performing well are greater than the outflows to performing poorly (Karceski (2002)) or because they are rewarded for beating the market, which presumably has a positive risk premium, on a non-beta-adjusted basis (Brennan (1993) and Baker, Bradley, and Wurgler (2011)). More generally, short-selling constraints inhibit sophisticated investors' ability to exploit an overpricing of high-beta stocks (Hong and Sraer (2016)).

This paper does not provide another attempt to resolve whether mispricing is the right term for this phenomenon. Rather, in the spirit of Stein (1996), who studies rational investment in the presence of capital market mispricing, we study rational leverage choices in the presence of a risk mispricing. Also, for our purpose, this is to some extent a semantic question. Whenever debt and equity markets are segmented and therefore not pricing risk in the same way—as in Fama and French (1993), who find that stocks and bonds exhibit distinct—there may be an opportunity to reduce the cost of capital by reallocating risk from debt to equity or vice-versa.

1.2. The risk anomaly and WACC arithmetic

Leaving aside leverage, the effect of a risk anomaly on the cost of capital is not subtle: higher risk investments have a lower cost of capital. This has clear implications for investment but its implications for capital structure depend on whether there is an equal-sized risk anomaly across the stock and bond market. There is little evidence in the prior literature or in our analysis in the next section that this is the case, but the exposition is easier if we start with a counterfactual risk anomaly that prices both stocks and bonds simultaneously.[3]

[3] The closest research appears to be Houweling, van Vliet, Wang, and Beekhuizen (2014) and Frazzini and Pedersen (2014), who find that short-maturity corporate bonds issued by low risk firms have marginally higher bond-market-beta risk-adjusted returns. Bond index betas are very different from stock index betas, however. Fama and French (1993) show that stock market betas are practically identical for bond portfolios of various ratings, and Baele,

Accordingly, suppose there is an integrated risk anomaly such that Equation (1) also holds for debt and debt betas, with subscripts *e* replaced with subscripts *d*. In this case, illustrated in Panel A of Figure 1, the Modigliani-Miller theorem is preserved. The cost of capital is

$$WACC = er_e + (1-e)r_d = (\beta_a - 1)\gamma + r_f + \beta_a r_p \ , \tag{2}$$

which depends on asset beta β_a and the size of the risk anomaly γ but is independent of capital structure *e*, the ratio of equity to firm value.

Now suppose that markets are segmented such that there is a risk anomaly in equity but debt is correctly priced by the CAPM as

$$r_d = r_f + \beta_d r_p \, . \tag{3}$$

In this case, illustrated in Panel B of Figure 1, the cost of capital depends not only on asset beta but on leverage:

$$WACC(e) = er_e + (1-e)r_d = r_f + \beta_a r_p + (\beta_a - 1)\gamma - (1-e)(\beta_d - 1)\gamma \, , \tag{4}$$

where debt beta, without any further loss of generality, is a function of leverage and the underlying asset risk. The second to last term—the asset beta minus one times γ—is the uncontrollable reduction in the cost of capital that comes from having high-risk assets. The last term is the controllable cost of having too little leverage while debt beta remains low.

Finally, it is possible that there is a large risk anomaly in equity and a smaller one in debt. This case, which is illustrated in Panel C of Figure 1, has qualitatively similar implications to the case of no risk anomaly in debt, but tilts firms toward higher levels of debt, all else equal. We omit the arithmetic.

Bekaert, and Inghelbrecht (2009) find that the magnitude and even the sign of the correlation (and beta) between government bond and stock index returns are unstable. These results thus provide little evidence of an integrated risk anomaly and are compatible with our own findings. More generally, Kisgen and Strahan (2010) and Chernenko and Sunderam (2012) point out that there is segmentation even within the debt markets due to little more than the artificial distinction between investment- and speculative-grade debt.

1.3. Further evidence on the risk anomaly

Here we extend prior evidence on the risk anomaly to confirm that the risk anomaly within the equity market does not extend across the stock and corporate bond markets. Along the way, we measure the size of the anomaly to use in later calibrations.

We estimate the relationship between equity returns and beta using data from January 1931 through December 2014 from the Center for Research in Securities Prices (CRSP) data. We include all industries. We compute results for the 47 years (564 months) since January 1968, when the number of stocks in the beta portfolios becomes large and which is not much before the beginning of our Compustat leverage sample, as well as the full sample of 84 years (1008 months) since January 1931. We use a minimum of 24 months and a maximum of 60 months of returns to estimate betas for each stock, and then form value-weighted bottom 30%, middle 40%, and top 30% beta portfolios.

The top panel of Table 1 shows that in the later sample, the low beta portfolio has a beta of 0.55 and an alpha of 28 basis points per month. In contrast, the high beta portfolio has a beta of 0.55 + 0.72 = 1.27 and an alpha of 28.4 - 60.4 = -32 basis points. The long-short beta portfolio thus has an alpha of -60 basis points despite a beta of 0.72. This is the risk anomaly. Based on a crude annualization, there was, in this sample, a 12*60/0.72 = 10% lower annual risk-adjusted cost of equity per unit increase in beta. In other words, $\gamma = -10\%$ in Equation (1).[4]

We plot this inverted security market line in Panel A of Figure 2. We also plot the mean excess returns on long-term corporate and government bonds over this period. It is apparent that any alpha in corporate bonds is simply due to a term premium in government bonds. However, even taking the corporate bond returns as pure alpha, the figure suggests that there is not an

[4] All results in this section are similar or stronger under the Fama-French three-factor model. Results are available on request.

integrated anomaly because the corporate bond returns fall so far below an extended security market line extrapolated from the stock portfolios.

The right columns of Table 1 provide a more formal rejection of an integrated risk anomaly. Using the difference in point estimates between the low and high risk stock portfolios, alpha should rise by 60/0.72 = 83 basis points per month for a unit reduction in beta. Hence, the alpha of the corporate bond portfolio, with a beta that is 0.39 lower, 'should be' 32 basis points higher than that of the low risk portfolio. The actual alpha falls 39 basis points short of this integrated markets target. The hypothesis of integration is strongly rejected. In the second panel of Table 1, the hypothesis is rejected even more strongly when the term premium is removed from corporate bonds.

The results are similar using data starting in 1931. The empirical security market line from stock returns is at least upward sloping, but there remains a large risk anomaly, with an estimate of γ = -7%. The bond returns again fall far below an extension of the empirical security market line, and the hypothesis of an integrated risk anomaly is again comfortably rejected.

In summary, the risk anomaly is either exclusive to the stock market or, at a minimum, the very same anomaly does not also explain the pricing of corporate debt. These results form the empirical basis for our normative, and eventually empirical, study of how leverage is chosen to exploit a risk anomaly.

2. The Risk Anomaly and Leverage

This section outlines a simple, static model of optimal capital structure with no frictions other than a risk anomaly confined to the equity markets. There are no taxes, transaction costs, issuance costs, incentive or information effects of leverage, or costs of financial distress or bankruptcy. It is interesting that unlike other tradeoff approaches, which require one friction or imperfection to limit leverage on the low side and another to limit it on the high side, this single mechanism can drive an interior optimum.

The most basic prediction we are working toward is that firms with high asset beta prefer low leverage. The natural benefit they acquire from the low beta anomaly deteriorates quickly with leverage, while low asset beta firms will pursue high leverage in order to capture it. Another important prediction suggests how to empirically distinguish the risk anomaly tradeoff from the costs of financial distress. If distress has a systematic component, for example, firms with high asset betas might optimally choose less leverage to minimize the present value of financial distress. Importantly, this prediction is asymmetric. It is downside beta that drives high leverage. By contrast, we show that upside beta is equally relevant under the risk anomaly tradeoff.

2.1. Theoretical observations

We assume a linear risk anomaly in equity and no anomaly in debt, as in Panel B of Figure 1 and Equations (1) and (3). A less important assumption is that the CAPM holds up to the risk anomaly in equity; any asset pricing model with a stronger risk anomaly in equity will lead to the same qualitative conclusions. The advantage of assuming sufficient conditions for the CAPM to hold in rational markets is that we can develop comparative statics using the familiar transfers of beta risk from equity to debt as leverage increases. Under these assumptions, WACC is given by Equation (4) above. We repeat it here for convenience:

$$WACC(e) = er_e + (1-e)r_d = r_f + \beta_a r_p + (\beta_a - 1)\gamma - (1-e)(\beta_d - 1)\gamma \, , \tag{4}$$

Again, as mentioned above, the second to last term is the reduction in the cost of capital that comes from having high-risk assets, while the last term is the controllable cost of having too little leverage while debt beta still remains low.

The optimal capital structure minimizes this last term by satisfying the first order condition for e. With the further assumption of a differentiable debt beta, for a given level of asset beta the optimal capital ratio e^* satisfies

$$-\gamma\left\{1-\beta_d\left[e^*(\beta_a),\beta_a\right]+\left[1-e^*(\beta_a)\right]\frac{\partial\beta_d\left[e^*(\beta_a),\beta_a\right]}{\partial e}\right\}=0 \tag{5}$$

or, in terms of optimal debt beta,

$$\beta_d^*\left[e^*(\beta_a),\beta_a\right]=1+\left[1-e^*(\beta_a)\right]\frac{\partial\beta_d\left[e^*(\beta_a),\beta_a\right]}{\partial e}\,.$$

Interestingly, the optimum leverage does not depend on the size of the risk anomaly. This is something of a technicality, however. If there were any other frictions associated with leverage, such as taxes or financial distress costs, the anomaly's size would become relevant.

2.1.1. Observation 1: Firms will issue some debt, and as much debt as possible as long as it remains risk-free

The first order condition cannot be satisfied as long as the debt beta is zero. At a zero debt beta, the left side of Equation (5) is positive (recall $\gamma < 0$). In other words, issuing more equity at the margin will raise the cost of capital. With zero debt, the asset beta is equal to the equity beta and the WACC reduces just like Equation (2):

$$WACC(1)=(\beta_a-1)\gamma+r_f+\beta_a r_p\,. \tag{6}$$

A first-order Taylor approximation around $e=1$ shows that even marginal debt will decrease the cost of capital:

$$WACC(e)\approx WACC(1)+(1-e)\lambda<WACC(1)\,. \tag{7}$$

At first blush, this would seem to deepen the so-called low leverage puzzle. One might ask why nonfinancial firms do not increase their leverage ratios further to take advantage of the risk anomaly: It is initially unclear how the low leverage ratios of nonfinancial firms represent an optimal tradeoff between the tax benefits of interest and the costs of financial distress, much less an extra benefit of debt arising from the mispricing of low risk stocks.

The answer contained in Equation (5) is that many low leverage firms—for example, the stereotypical unprofitable technology firm—already start with a high asset beta or overall asset risk. Their assets are already quite risky at zero debt. Even at modest levels of debt, meaningful risk starts to be transferred to debt. While Equation (5) cannot on its own explain why a firm would have exactly zero debt, it can explain why some firms have low levels of debt, despite the interest tax benefits and modest costs of financial distress.

2.1.2 Observation 2: The optimal leverage ratio has an interior solution

We have just shown zero debt is not optimal. Zero equity is also not optimal. If the company is fully debt financed, the debt beta equals the asset beta and Equation (4) reduces to that of the traditional WACC formula without the risk anomaly. This establishes that the optimum leverage must be an interior solution. The intuition is that, with the assumption of fairly priced debt, the firm will be fairly priced if it is funded entirely with debt, i.e. 100% leveraged. Can it increase value by shifting its leverage ratio down somewhat? Yes. This new equity, an out of the money call option, will be high risk, and hence overvalued. As a consequence, neither 0% nor 100% leverage are optimal, so the optimal leverage must be an interior optimum.

So far, our only assumption is a risk anomaly in equity. To further our understanding of optimal debt levels, we must make sufficient assumptions to characterize the dynamics underlying transfer of risk from equity to debt with increasing levels of leverage, and in particular the dependence of debt beta on leverage. A leading candidate for the functional form of debt betas is the Merton (1974) model. Merton uses the isomorphic relationship between levered equity, a European call option, and the accounting identity $D = V - E$ to derive the value of a single, homogenous debt claim, such that

$$D(d,T) = Be^{-r_f \tau}\Phi\left[x_2(d,T)\right] + V\left\{1 - \Phi\left[x_1(d,T)\right]\right\}, \tag{8}$$

where V is firm value with volatility σ, D is the value of the debt with maturity in τ and face value B. Let $T = \sigma^2\tau$ be the firm variance over time, and $d \equiv \frac{Be^{-r_f \tau}}{V}$ the debt ratio, where debt is valued at the risk free rate, thus d is an upward biased estimate of the actual market based debt ratio (Merton, pp. 454-455). Here, $\Phi(\mathbf{x})$ is the cumulative standard normal distribution and x_1 and x_2 are the familiar terms from the Black-Scholes formula.

Following the approach of Black and Scholes (1973), we arrive at the debt beta:

$$\beta_d = \beta_a \frac{V}{D} D_V . \tag{9}$$

Here D_V is the first derivative of the debt value given in Equation (8) with respect to firm value V. In the Merton model, the debt value is equivalent to a riskless debt claim less a put option. Using this property, it follows that the derivative D_V is equivalent to the negative of the derivative of the value of this put option. That is, the derivative (or delta) of the put option on the underlying firm value is $\Delta_{put} = -\left[1 - \Phi(x_1)\right]$, thus $D_v \equiv -\Delta_{put} = 1 - \Phi(x_1)$. Substituting for Equation (4), the debt beta in the Merton model can be written as

$$\beta_d = X(d)\beta_a, \tag{10}$$

where $X(d) = \frac{1-\Phi(x_1)}{d\Phi(x_2)+1-\Phi(x_1)}$ is positive. Further, we have that the debt beta is bounded:

$\lim_{d \to 0}\left\{\beta_d = X(d)\beta_a\right\} = 0$, and

$$\lim_{d\to\infty}\left\{\beta_d = X(d)\beta_a\right\} = \beta_a,$$

in line with the boundary conditions of the indenture of the debt and in support of the limiting conditions necessary to establish the claim of an interior optimum leverage.

The factor $\Phi(x_1)$ is equivalent to the Black-Scholes delta of an equity claim with spot price equal to firm value *V* and exercise price equal to face value of the debt claim *B*. In light thereof, the debt beta can be seen to be driven by the increasing value loss in default. If $\beta_a > 0$ then the debt beta will be continuous and strictly increasing in *d*. Now rewriting Equation (10),

$$\beta_d = \beta_a \frac{V - V\Phi(x_1)}{D}, \tag{11}$$

and following the limits above it can be seen that $0 \le V - V\Phi(x_1) \le D$. Consequently, $V\Phi(x_1)$ in Equation (11) can be interpreted as the conditional expectation of firm value given it is larger than the face value of debt, times the probability of the firm value being larger than the face value of debt. This is effectively the amount of firm risk carried by the debt.

On closer inspection, the debt beta in Equation (10) can be written, showing its full functional dependence, $\beta_d(d,\beta_a,T)$. In our framework, however, the measure of leverage is not *d*, but rather the market based capital ratio, *e*, that is given by

$$e(d,T) = \frac{V - D}{V} = \Phi(x_1) - d\Phi(x_2), \tag{12}$$

and is continuous and strictly decreasing on *d*.

By expressing the debt beta in Equation (10) parametrically as a function of the equity ratio in Equation (12) with *d* as a shared parameter, holding all else equal, the derivative of the debt beta in Equation (5) is equivalent to

$$\frac{\partial\beta_d(e(d,T),\beta_a,T)}{\partial e(d,T)} = \frac{\partial\beta_d(d,\beta_a,T)/\partial d}{\partial e(d,T)/\partial d},$$

and

$$\frac{\partial\beta_d(d,\beta_a,T)/\partial d}{\partial e(d,t)/\partial d} = -M\left(d\right)\beta_a. \tag{13}$$

The intuition behind the function $M(d)$ is not important here. The first feature of $M(d)$ is that it does not depend on the asset beta β_a itself. What that means is that we can separate out the transfer of risk—which depends on d and the distribution of firm values characterized by the Black-Scholes inputs of total risk, time to maturity, the riskless rate, and the face value of debt—from the specific risk transferred:

$$M(d) = \frac{\Phi(x_1)\Phi(x_2) + \Phi(x_2)\frac{\phi(x_1)}{\sigma\sqrt{\tau}} + \left[1-\Phi(x_1)\right]\frac{\phi(x_2)}{\sigma\sqrt{\tau}} - \Phi(x_2)}{\left[1-\Phi(x_1)+d\Phi(x_2)\right]^2\left[\Phi(x_2) - \frac{\phi(x_2)}{\sigma\sqrt{\tau}} + \frac{\phi(x_1)}{d\sigma\sqrt{\tau}}\right]}. \tag{14}$$

A second feature of M is that it is positive, so the debt beta falls as the capital ratio increases.

2.1.3 Observation 3: The optimal leverage ratio is decreasing in asset beta

This is perhaps the most fundamental observation. With the Merton assumptions, and with no frictions other than a risk anomaly in equity, the optimal level of capital, e^* in Equation (5), can be expressed with Equation (10) and (13) as

$$e^*(d^*,\beta_a) = 1 - \frac{1}{M(d^*)}\left(\frac{1-\beta_d(d^*,\beta_a)}{\beta_a}\right) = 1 - \frac{1}{M(d^*)}\left(\frac{1}{\beta_a} - X(d^*)\right). \tag{15}$$

Holding the positive functions X and M constant—we are varying the asset beta without changing the overall level of risk—the optimal level of capital is increasing in asset beta:

$$\frac{\partial e^*(d^*,\beta_a)}{\partial\beta_a} = \frac{1}{M(d^*)\beta_a^2} \geq 0. \tag{16}$$

We outlined the intuition for Equation (16) in the introduction. Risk is overvalued in equity securities and fairly valued in debt securities. Ideally, to minimize the cost of capital, risk is concentrated in equity. This leads to the first observation that firms will issue as much risk-free debt as possible. This lowers the WACC through an increase in the cost of equity due to its increased risk. Once debt becomes risky, further increases in leverage, or reductions in equity capital *e*, have a cost. At that point, *M* is greater than zero. Shifting overvalued risk in equity securities to fairly valued risk in debt increases the cost of capital. For firms with high-risk assets, this increase is high even at low levels of leverage. For firms with very low risk assets, this increase remains low until leverage is high.

More formally, we can show that:

$$\frac{\partial \beta_d(e,\beta_a,T)}{\partial e} < 0 ,$$

$$\frac{\partial \beta_d(e,\beta_a,T)}{\partial \beta_a} \geq 0 \text{, and}$$

$$\frac{\partial^2 \beta_d(e,\beta_a,T)}{\partial \beta_a \partial e} < 0 . \tag{17}$$

The first two partial derivatives of the debt beta with respect to the equity ratio and the asset beta follow directly from Equation (11) and the assumption that $\beta_a > 0$. Furthermore, since the asset beta is simply a scalar and positive, the cross-partial derivative with the equity ratio must have the same sign as the partial derivative with respect to the equity ratio.

We can now sign the change in the optimal capital ratio as a function of the underlying asset beta in the more general case. Taking the derivative of e^* with respect to the asset beta:

$$\frac{de^*(\beta_a)}{d\beta_a} = -\left[-\frac{\partial \beta_d\left(e^*,\beta_a\right)}{\partial \beta_a} + \left[1-e^*(\beta_a)\right] \frac{\partial^2 \beta_d\left(e^*,\beta_a\right)}{\partial e \partial \beta_a} \right] \times$$

$$\left[-2\frac{\partial \beta_d\left(e^*(\beta_a),\beta_a\right)}{\partial e}+\left[1-e^*(\beta_a)\right]\frac{\partial^2 \beta_d\left(e^*(\beta_a),\beta_a\right)}{\partial e^2}\right]^{-1}. \tag{18}$$

The first term is positive using the signs of the partial derivatives in Equation (17). The second term is the second order condition at the optimal leverage ratio defined in Equation (5). It follows from Cargo (1965) that the second order condition is positive, if and only if both the debt beta in Equation (10) and one minus the capital ratio in Equation (12) are strictly increasing functions in *d* and Equation (13) is negative, which we have already established.

2.1.4 Observation 4: Upside and downside asset beta are equally important in determining optimal leverage.

It is important to derive a prediction that allows us to empirically separate the risk anomaly tradeoff from the costs of financial distress and the traditional tradeoff. To do this, we observe that in the traditional tradeoff, only downside beta, not upside beta, increases the costs of financial distress and therefore reduces optimal leverage. In contrast, in the risk anomaly tradeoff, the effect is symmetric. To show this, we repeat the previous exercise but using a version of Equation (1) that separates overall beta into upside and downside components:

$$r_e=\left(\beta^+ + \beta^- -1\right)\gamma + r_f + \left(\beta^+ + \beta^-\right) r_p, \tag{19}$$

where we define upside and downside beta in the spirit of Markowitz (1959) and Hogan and Warren (1974).[5]

We can now substitute a decomposition of the asset beta as in Equation (19) into Equation (15),

$$\beta_a = \beta_a^{\ +} + \beta_a^{\ -}, \tag{20}$$

[5] $\beta \equiv \frac{1}{\mathrm{var}(r_m)} n^{-1}\left[\sum_{j=1}^{n}(r_{i,j}-\mu_i)(r_{m,j}-\mu_m) I_{r_{m,j}>T} + \sum_{j=1}^{n}(r_{i,j}-\mu_i)(r_{m,j}-\mu_m) I_{r_{m,j}\le T}\right] = \beta^+ + \beta^-.$

which implies that the optimal capital structure takes the following form:

$$e^*(d^*,\beta_a) = 1 - \frac{1}{M(d^*)}\left(\frac{1}{\beta_a^+ + \beta_a^-} - X(d^*)\right). \tag{21}$$

This means that once again holding the positive functions *X* and *M* constant, the optimal level of capital is rising to the same degree in both upside and downside asset beta, as in Equation (16).

Again, there is a straightforward intuition for Equation (21). The character of total risk, as defined in the functions *M* and *X,* is what dictates the transfer of risk from equity to debt. Holding this transfer of risk constant, the optimal level of capital is increasing in any measure of mispriced asset risk, whether upside or downside.

2.1.5 Observation 5: A negative empirical relationship between equity beta and leverage is sufficient to prove a negative empirical relationship between asset beta and leverage

Our central prediction is a link between asset beta and leverage. In the absence of tax benefits and incentive effects of debt, firms with low asset betas choose higher leverage in the presence of a risk anomaly in order to reduce the overall cost of capital. In our empirical analysis we look for a negative relationship between asset beta and leverage. However, to measure asset beta directly, all of the firm's liabilities must be traded, which is rarely the case, so the traditional method of estimating asset beta is simply to assume that debt betas are zero.

We can avoid having to condition a negative leverage-asset beta link on a zero debt beta assumption by noting that if leverage rises with a decrease in equity beta, then asset beta must fall too through a simple Modigliani and Miller logic and absolute priority of returns. If we find that the equity beta is lower and leverage is higher, then the asset beta must be lower. Thus, a negative relationship between equity beta and leverage implies a negative relationship between asset beta and leverage.

2.2 A calibration

Here we assume the model is correct, including its absence of other frictions, and make some basic calculations about the value of optimally exploiting the risk anomaly. To keep things simple, we use the Black and Scholes (1973) assumptions and a single liquidation date, five years forward, with a contractual allocation of value between debt and equity and no costs of financial distress. For each level of leverage, we compute the value of debt, the value of equity, and the equity beta using the Merton model. Although this simple approach is a far cry from structural estimations of dynamic capital structure models, this exercise may provide a degree of insight into the potential empirical relevance of the anomaly for leverage.

Figure 3 shows the cost of capital and firm value as a function of leverage for a variety of asset risk levels. In the absence of a risk anomaly, cash flows both grow and are discounted at the CAPM rate, so firm value is the same, at $10 under our assumptions, at all asset risk levels. In the Figure we modify the value of equity using the risk anomaly in Equation (1) of γ = -5% per year. This is conservative relative to the historical estimates from Table 1, which suggest an anomaly of -10% per year for the 1968-2014 sample and -7% for the 1931-2014 sample.

The figure shows how a high equity beta uses the anomaly to raise value. A low equity beta reduces value, and then some, in passing it up. Because the only effects here are through the weighted average cost of capital, with no cash flow effects, a weighted average cost of capital minimum in Panel A is equivalent to a firm value maximum in Panel B. Finally, under a risk anomaly, high asset risk means higher valuations at any level of leverage. Panel C removes this effect and shows value levels relative to the maximum for each level of asset risk. At least under these calibration parameters, not exploiting the risk anomaly can substantially reduce firm value.

3. Empirical Tests

3.1. Hypotheses

The theoretical observations above lead to three testable hypotheses. They are all geared to establishing that there exists a negative relationship between leverage and asset beta that can be—at least in part—tied to the risk anomaly tradeoff.

3.1.1. Hypothesis 1. Leverage is negatively related to asset beta

This hypothesis is motivated by Observation 3. Support for this hypothesis is best viewed as a necessary condition for the risk anomaly tradeoff to be empirically relevant, however, in the sense that it cannot on its own rule out alternative hypotheses based on financial distress. Long and Malitz (1985) and Schwert and Strebulaev (2014), among others, propose this explanation for a negative link between leverage and asset risk. To provide unique evidence for the risk anomaly channel, we test the following hypothesis.

3.1.2. Hypothesis 2. Leverage is negatively related to both upside and downside beta

Under a standard tradeoff where financial distress reduces the attractiveness of debt, all else equal, one expects a negative relationship between leverage and proxies for distress risk such as, potentially, asset beta. Observation 4 helps us rule this alternative explanation out.

Observation 4 hinges on Equation (19) which says that there is a linear risk anomaly: The slope γ is constant across the full distribution of β, as it is in the model of Brennan (1993) and as emphasized by Baker, Bradley, and Wurgler (2011). If anything, other theories suggests that the risk anomaly might be stronger in the range of positive β^{+}. Karceski (2002) points out that flows into equity mutual fund follow periods of strong overall market returns. When these flows arrive, they go to the very best performing mutual funds, according to Sirri and Tufano (1998). The ex ante business incentive for managers of these mutual funds is then to avoid poor performance, conditional on high market returns. This says that mutual fund managers might be willing to overpay for high upside beta. Hong and Sraer (2016) focus on the interaction between overconfidence and high beta, or more speculative, stocks. These stocks have greater disagreement and, under short sales constraints, are more overvalued. A richer model might feature greater overconfidence in periods of rising market returns and in principle deliver a stronger risk anomaly in upside betas.

These predictions stand in contrast to the traditional tradeoff theory and the arguments in Almeida and Philippon (2007) or Shleifer and Vishny (1992). The costs of financial distress depend not only on the unconditional probability of default and value lost in default but also when distress occurs and value is lost. If asset beta, holding all else constant, including total risk, dictates the market state when distress is likely to occur, then the present value of the costs of financial distress are higher for assets with higher systematic risk.

Almeida and Philippon (2007) argue that risk-adjustment increases the cost of financial distress. Shleifer and Vishny (1992) offer the tangible example of refinancing risk and fire sales. If refinancing risks and fire sale discounts are higher during market downturns, this would increase the value lost in distress and lower optimal leverage for firms with higher levels of systematic risk, although it is still hard to justify zero debt in the presence of large tax benefits.

An important point is that in the traditional tradeoff, "downside risk" is the emphasis. Risk matters because of bankruptcy costs. (If anything, upside risk actually tends to increase optimal leverage by increasing expected tax benefits.) Hence, if a beta risk version of the traditional tradeoff drives an empirical link between high asset beta and leverage, it should be most apparent using downside risk. The risk anomaly tradeoff makes no such distinction. Upside and downside risk are equally relevant and should both be negatively related to leverage.

3.1.3. Hypothesis 3. Leverage is negatively related to equity beta

This is based on Observation 5, which notes that a negative empirical relationship between equity beta and leverage is sufficient to prove a negative empirical relationship between asset beta and leverage, our main point. Again, the utility of this prediction is that it allows us to avoid conditioning any negative leverage-asset beta empirical relationship on the assumption of zero debt beta which, as an empirical matter, is almost unavoidable. In our empirical tests, we address both the financial distress risk alternative explanation and the zero debt beta assumption at once by relating leverage to upside and downside equity beta.

3.2. Data

Our main variables are introduced in Table 2. Our basic sample is the portion of the merged CRSP-Compustat sample for which marginal tax rates are available from John Graham. The data begin in 1980, when marginal tax rates are first available, and end in 2014. They contain 1,038,097 firm-months and span all 50 Fama-French (1995) industries. Unlike much capital structure research, we include financial firms because they are not special under the risk anomaly theory, but their exclusion does not affect the relevant results. In an average cross-section there are 2,181 profitable and 291 unprofitable firms.

Variable definitions are detailed in Appendix 1. Gross book leverage is long-term debt and notes payable divided by the sum of long-term debt and notes payable plus book equity. Net book leverage nets out cash and equivalents from the numerator and denominator. Gross and net market leverage replace book equity with the market value of common equity from CRSP.

The regressions control for traditional explanatory variables in Bradley, Jarrell, and Kim (1984), Rajan and Zingales (1995), Frank and Goyal (2009), and others. The fixed assets ratio, a proxy for financial distress costs, is net property, plant and equipment divided by total assets.

Profitability, which would be positively correlated with leverage under the standard tradeoff theory but inversely correlated under the Myers and Majluf (1984) pecking order, is EBIT divided by total assets. Market-to-book assets is known to be negatively related to leverage, consistent with the need for firms with strong growth opportunities to avoid having to pass them up (Myers (1977)) as well a more passive lack of adjustment of leverage to prior stock returns (Welch (2004)). It is gross debt and market equity divided by the sum of gross debt and book equity. Asset growth could be a proxy for growth opportunities or capture size or the profitability that helps to make debt-financed acquisitions. Size, measured as the natural log of book assets, may also proxy for multiple influences. Fama and French (1992) use it to represent the greater cash flow volatility of smaller firms and their higher expected costs of financial distress. It will also reflect their lesser access to debt markets. Finally, John Graham's pre-interest marginal tax rates account for many features of the tax code. As shown by Graham and Mills (2008), these approximate the tax rates simulated with federal tax return data.

The leverage determinants that interest us most are constructed from stock returns. Asset beta is unlevered equity beta, assuming debt is riskless. It is hard to do better without debt returns data, and betas on corporate debt are very low, but to avoid the results depending on this assumption we also test wheter equity beta is negatively related to leverage (Observation 5). Total equity risk is the standard deviation of excess stock returns. Asset risk is the unlevered version. Industry asset beta and risk are market equity-weighted averages.

3.3. Summary statistics

Tables 2 and 3 show summary statistics and correlations. Profitable firms are larger and have higher tax rates. Asset beta is somewhat higher for unprofitable firms, as is total risk, which we will use as a control variable for financial distress costs. With respect to asset risk, a firm must be promising and at least on a path to profitability to enter the CRSP-Compustat sample for the 24 months that we require to compute beta. Becoming unprofitable may be associated with unexpectedly negative returns; also, firms in variable industries are more likely to find themselves unprofitable in a given period. The latter logic also applies to beta, on the downside.

Other notable correlations in Table 3 are as follows. Gross and net leverage measures are loosely correlated enough to consider both as a robustness exercise. We follow tradition and consider both book and market leverage measures. Asset beta, for the own firm or the industry, is negatively correlated with tax rates and fixed assets and positively correlated with market-to-book and size. These correlations are generally small relative to the correlations among the various risk measures.

3.4. Extreme leverage

Although firms at the leverage extremes are not uncommon, they are particularly interesting to consider in light of the risk anomaly because they are where the standard tradeoff theory is least compelling. In particular, a risk anomaly tradeoff could help to explain some of the low leverage puzzle broached by Miller (1977) and documented by Graham (2000). As an example, Linear Technology Corporation (Nasdaq: LLTC) produces semiconductors with a market capitalization of $7.7 billion as of December 2012. Despite profitable operations, a pre-interest marginal tax rate of 35% by the methodology in Graham and Mills (2008), and a cash balance of $1 billion, Linear maintains negative net debt. One potential explanation for this may be its high asset beta.

While rarer than inexplicably low-leverage firms, a number of profitable firms maintain high leverage despite little tax benefit. Under a standard tradeoff theory, this amounts to needlessly tempting a fate of financial distress. An example is Textainer (NYSE: TGH), a firm that leases and trades marine cargo containers. As of the end of 2012, its market capitalization was approximately $1.7 billion. It has tangible assets of $3.4 billion and a cash balance of $175 million. Despite a marginal tax rate close to 0%, as a result of front-loaded depreciation, modest growth, and an offshore tax status, it maintains $2.7 billion in debt. A potential explanation for this inconsistency with the standard tradeoff theory is the firm's low asset beta. Under a risk anomaly, equity is undervalued at low leverage, and its value rises steadily as leverage increases to its correct valuation, and potentially beyond.

The risk anomaly tradeoff may also be pertinent to a set of uniquely highly leveraged firms—banks—which are often excluded from capital structure analyses. Figure 3 suggests that a risk anomaly in equities means that regulating low asset beta firms, in the sense of requiring them to delever significantly, can impose large increases in the cost of capital and losses in shareholder value. Baker and Wurgler (2015) find that banks' asset betas are on the order of 0.10, and that the risk anomaly within banks is at least as large as for all firms. While there are numerous other forces at play in regulatory debates, the loss of the risk anomaly's benefits gives a coherent foundation for bankers' common argument that reducing leverage would increase their cost of capital (e.g., Elliott (2013)).

Table 4 looks more closely within profitable firms, where we have 867,524 observations and the shortcomings of the standard tradeoff theory appear most clearly. The panels separate profitable firms into low leverage (gross book leverage <5%) and high leverage (gross book leverage >50%) groups. What counts as high leverage is subjective. We obviously cannot expect a mode at 100% that resembles the mode at 0%, so we choose an arbitrary cutoff of 50%. The columns then add another sort into low (MTR<5%), medium, and high (MTR>30%) marginal tax rate groups.

The low leverage puzzle is represented in the large number of firm-months that have chosen very low leverage despite positive profitability and high marginal tax rates. In the average cross-section, not far from half of firms in the highest tax category, 43%, have chosen low leverage over high leverage (43% = 283/(283+371)). Firms like Linear Technology are here. The high leverage puzzle, if we can call it that for sake of illustration, is the narrower but still noticable fact that nearly half of the firms in the low tax category, 47%, have chosen high leverage (47% = 19/(17+19)). Firms like Textainer are in this bin.[6]

Some initial support for the risk anomaly tradeoff comes from the much stronger differences in asset risk across the leverage levels. Within the middle tax rate group, for example, asset betas decline sharply with leverage. Firms with very low leverage have a median asset beta of 1.14, a median upside asset beta of 0.83, and a median downside asset beta of 1.40. For high leverage firms this falls to 0.37, 0.26, and 0.45, respectively.

3.5. Regressions

Turning from extreme leverage observations to the broader cross-section, the first column in Panel A of Table 5 shows a baseline gross book leverage regression using typical covariates. We report marginal effects of Tobit regressions that cluster on both firm and month. The first several variables' signs and effects are consistent with prior research, as is the poor overall R^2. The marginal tax rate has a positive coefficient, fixed assets a fairly strong positive coefficient, profitability a negative coefficient, market-to-book a negative coefficient, and size a positive coefficient. Rajan and Zingales (1995) focus on the latter four variables and obtain the same results. Asset growth has a positive coefficient, more consistent with the interpretation that asset

[6] This is certainly not the only approach to explaining extreme leverage. For example, Denis and McKeon (2012) explain it as an outcome of the evolution of operating needs and the desire to maintain financial flexibility; see also Hackbarth and Mauer (2011). Hackbarth (2009) suggests a role for managerial optimism.

growth is a consequence of the ability and desire to finance with debt, determined by other underlying sources, than an additional proxy for growth opportunities.

3.5.1 Leverage and asset beta

We now add risk measures to test Hypothesis 1. Our special focus is on asset beta, which is what the risk anomaly tradeoff suggests, but we also control for overall risk. In principle, any effect of total asset risk could reflect the risk anomaly tradeoff—some explanations of the risk anomaly are specific to beta, others are not. Total asset risk is a plausible proxy for the expected costs of financial distress, especially compared to asset beta.

The middle columns of Panel A show that asset beta is a strong determinant of leverage, consistent with Hypothesis 1. This is true controlling for overall asset risk (as well as in unreported univariate regressions). Adding the control variables does not significantly affect the coefficient or t-statistic on asset beta. With all controls, a one-unit increase in asset beta reduces leverage by 12.6%, a large effect by the standards of the control variables.

The last columns of Table 5 show that the economic effects remain if we use industry risk, which is an empirical solution to the issue of any mechanical negative link between leverage and asset beta created by using leverage itself to unlever equity beta. It appears that any measurement error introduced by this switch does not appear to greatly affect the coefficients on beta risk. These regressions provide further support for Hypothesis 1.

3.5.2 Upside and downside asset beta

We turn next to Hypothesis 2. It is clear that high asset beta is associated with lower leverage. This is consistent with the risk anomaly tradeoff whereby the cost of equity for high beta assets is lower and so less debt is optimal, but also consistent with versions of the standard tradeoff theory to the extent that the relationship is driven by downside risk. To examine whether downside risk alone is driving the relationship, we estimate equity beta separately over months when the market risk premium was positive and when it was negative. Unlevering these and averaging by industry gives us an upside asset beta and downside asset beta measure.

In Panel B of Table 5 we find that the upside and downside components of asset beta have an equally strong relationship to gross book leverage when using the firm's own risk measures and the relationship actually favors the upside asset beta upon using the preferred industry-based measures. The downside component of asset beta has no statistical association with leverage and in one case a point estimate of the wrong sign to support a systematic risk version of the traditional tradeoff theory.

Reassuringly for the traditional tradeoff, and consistent with our use of asset risk as a control variable for financial distress, the downside overall asset risk association with leverage is generally stronger than the upside asset risk association. This of course does not alter the conclusions relevant to Hypothesis 2, a prediction involving asset beta risk. To repeat, our goal is not to cast doubt on the relevance of the traditional tradeoff theory, merely to show that there is empirical support for a connection between leverage and asset beta that cannot be explained by a relationship through financial distress.

Support for Hypotheses 1 and 2 also appears under other leverage measures, including gross market leverage and net book and market leverage, still using industry risk measures. Panel A of Table 6 shows results consistent with only a risk anomaly tradeoff, in the form of an upside beta effect, remain strong, as well as results consistent with both a risk anomaly tradeoff and a traditional tradeoff, remain in the form of downside risk effects.

3.5.3 Upside and Downside Equity Beta

We now test Hypothesis 3, which addresses the required practical assumption of a zero debt beta. While debt betas in practice are very low, Hypothesis 3, which is based on the theoretical observation that a negative empirical relationship between leverage and equity beta is sufficient to prove a negative empirical relationship between leverage and asset beta, gives us a more grounded way to avoid conditioning our asset beta results on this assumption.

The results in Panel B of Table 6 confirm a negative relationship between leverage and equity beta. The result that upside beta risk is much stronger than downside beta risk remains. It is worth noting that any mechanical link between leverage and equity beta would bias results in a positive direction, i.e., away from our hypotheses of interest, so it is particularly comforting that the results remain strongly consistent with the risk anomaly tradeoff.

4. Conclusion

Many studies have shown that high-risk equities do not earn commensurately high returns. This paper derives a novel explanation for leverage that is consistent with this observation. We show that for firms with relatively risky assets, the cost of capital is minimized at a low level of leverage. For firms with very low risk assets, low leverage entails a substantial cost in the form of issuing undervalued equity, and hence the cost of capital is minimized at much higher levels of leverage. In the data, leverage is indeed inversely related to systematic risk, supporting the main prediction of the risk anomaly tradeoff.

Importantly, we derive and test a prediction of the risk anomaly tradeoff that allows us to separate it from a standard tradeoff explanation in which asset beta reflects financial distress costs. The risk anomaly tradeoff predicts that leverage is inversely related to upside risk, not just downside risk. This is also confirmed. In some specifications, the relationship between leverage and upside risk is stronger than the relationship with downside risk.

More broadly, we suggest that the risk anomaly tradeoff may help to explain the low and high leverage puzzles in which leverage choices cannot be easily explained by tax and financial distress considerations alone. Better understanding the empirical limits of the risk anomaly tradeoff, and how it complements other realistic explanations for leverage, is an area for future research.

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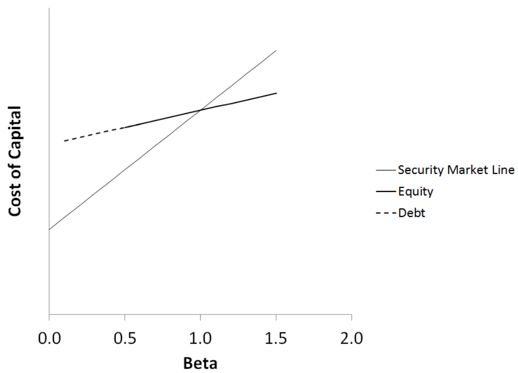
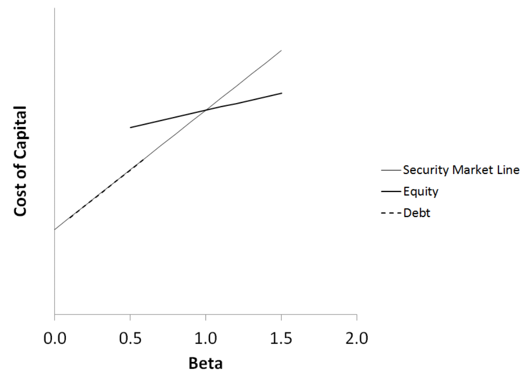
Figure 1. Segmented Debt and Equity Markets. For the risk anomaly to impact the weighted average cost of capital, debt and equity markets must be segmented. Panel A shows a risk anomaly that extends across asset classes, e.g. from safe debt with very low beta to equity with higher beta, rendering capital structure irrelevant. Panels B and C show segmented debt and equity markets, first with debt correctly priced and then with a small risk anomaly.

Panel A. Integrated Debt and Equity Markets



Panel B. Markets Not Integrated, Debt Correctly Priced



Panel C. Markets Not Integrated, Small Low Risk Anomaly in Debt Markets

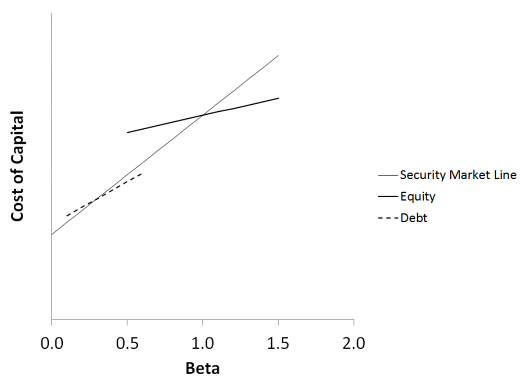
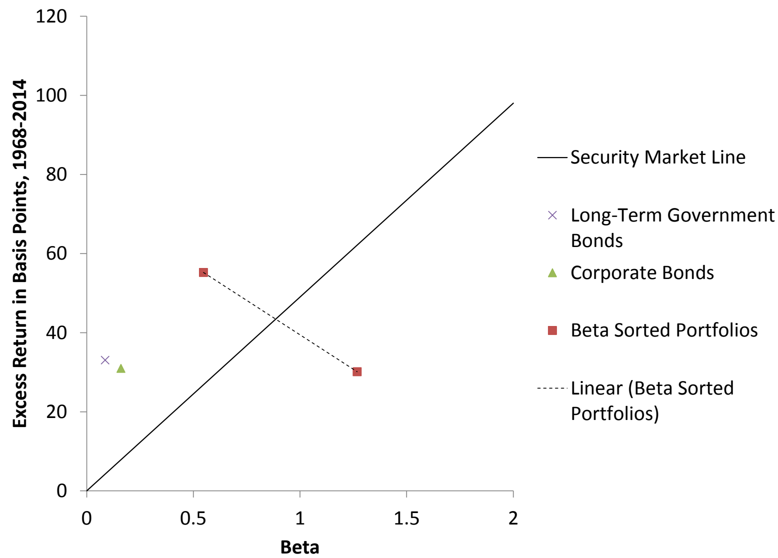


Figure 2. Bond Returns and the Risk Anomaly in Stocks. Plots of average returns and CAPM betas for two value weighted equity portfolios, bottom and top 30% according to a pre-ranking beta sort, as well as long-term corporate and government bonds from Ibbotson and Associates. The returns and betas are estimated for the top and bottom 30% as in Table 1. An empirical security market line is fit through the two equity portfolio data points.

Panel A. 1968-2014



Panel B. 1931-2014

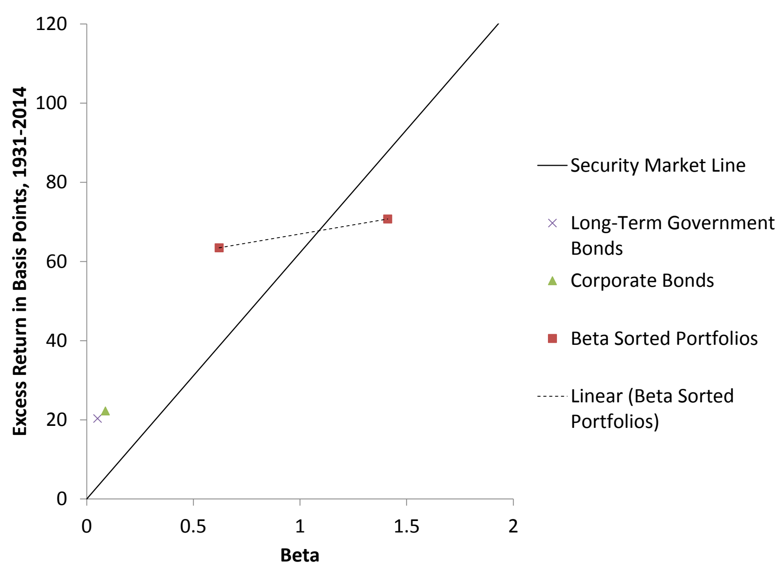
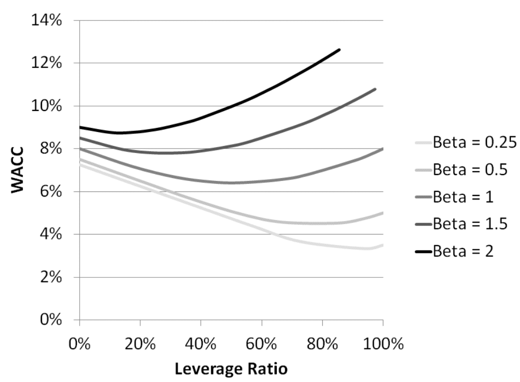
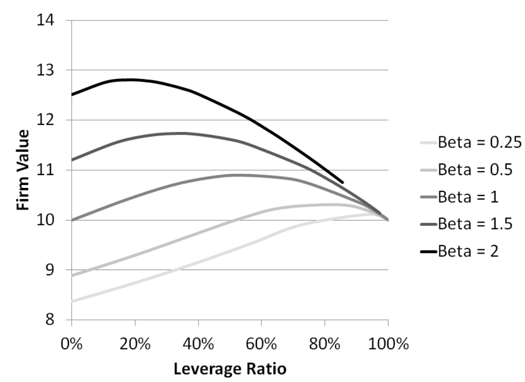


Figure 3. Value Effects of Leverage When There is a Risk Anomaly in Equities. We compute firm value for firms with five different levels of asset beta. Each firm has a normally distributed terminal value five years hence, with a contractual distribution of value between debt and equity and no costs of financial distress or tax effects. The value of each firm would be exactly \$10, regardless of leverage, if there were no low-risk anomaly. Volatility is equal to asset beta times the sum of a market volatility of 16% plus an idiosyncratic firm volatility of 20%. The risk free rate is 2%. We compute the value of equity, the value of debt, and the equity beta under the Merton model with no risk anomaly. We compound this equity value using the CAPM expected return with a market risk premium of 8% over five years. This means that a firm with a beta of 0.25 (beta of 2.0) has a weighted average cost of capital of 4% (18%) in the absence of a risk anomaly. We then present value this future equity value using the discount rate from Equation (1) with a γ of 5%. This is the adjusted equity value. The weighted average cost of capital uses the adjusted equity value and the value of debt as weights, the cost of equity from Equation (1), and the CAPM expected return for debt. Firm value is the adjusted equity value plus the value of debt. Leverage is computed using these market values.

Panel A. Weighted Average Cost of Capital



Panel B. Absolute Firm Value



Panel C. Firm Value Relative to the Maximum

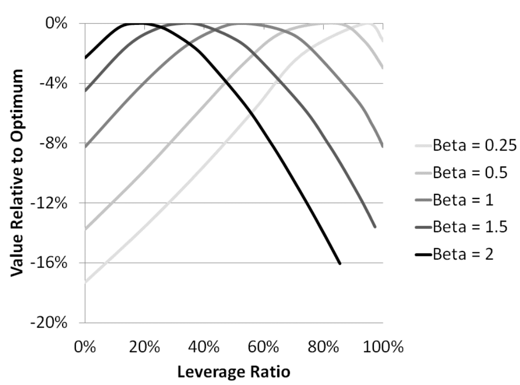


Table 1. The Risk Anomaly and Equity Market Segmentation. Regressions of portfolio returns on market excess returns and government bond excess returns. Each portfolio total return in excess of the riskless rate is computed using value weights. The sample is divided within each month into low (bottom 30%), medium (middle 40%), and high (top 30%) portfolios according to pre-ranking beta estimated on a minimum of 24 and a maximum of 60 months of returns, using all CRSP stocks and CRSP's value-weighted market return series. We also compute the returns to corporate bonds in excess of the riskless rate using data from Ibbotson Associates. Below we show the market beta, government bond beta, and the alpha (or intercept) for the Bottom 30% portfolio in absolute terms and for the Top 30% portfolio and corporate bonds in relation to the Bottom 30%. The final column compares the extrapolated alpha using the relationship between alpha and beta in the Bottom and Top 30% portfolios to the actual alpha for corporate bonds. In an integrated market, where the low beta anomaly holds equally in stock and bond markets, the actual and extrapolated betas are the same. To compute a p-value we draw from a multivariate normal distribution using the OLS estimates and covariances for the coefficients in the first three columns. For each of 10,000 draws, we compare the actual and extrapolated alpha. A one-tailed p-value of 0.095, for example, indicates that approximately 950 of the random draws feature an actual alpha that is higher than the extrapolated alpha. There are 564 months in the first two panels and 1,008 months in the second two panels.

	Bottom 30%		*Top - Bottom 30%*		*Corporate – Bottom 30%*		*Extrapolated Corporate – Bottom 30%*	
Basis Points	**Coef**	**[t]**	**Coef**	**[t]**	**Coef**	**[t]**	**Coef**	**[prob]**
CAPM Regressions, January 1968-December 2014								
Market	0.55	[28.31]	0.72	[26.35]	-0.39	[-14.23]		
Intercept	28.4	[3.19]	-60.4	[-4.79]	-6.6	[-0.53]	32.6	
Difference							-39.3	[p =0.009]
R-Squared								0.76
CAPM Regressions with Government Bond Returns, January 1968-December 2014								
Market	0.53	[33.48]	0.75	[33.09]	-0.44	[-19.72]		
Bonds	0.15	[6.45]	-0.28	[-8.44]	0.61	[18.33]		
Intercept	24.6	[3.36]	-53.3	[-5.17]	-22.0	[-2.13]	31.8	
Difference							-53.8	[p<0.001]
R-Squared								0.84
CAPM Regressions, January 1931-December 2014								
Market	0.62	[53.73]	0.79	[48.38]	-0.54	[-32.75]		
Intercept	22.0	[3.53]	-45.4	[-5.16]	-4.5	[-0.51]	30.8	
Difference							-35.3	[p =0.002]
R-Squared								0.86
CAPM Regressions with Government Bond Returns, January 1931-December 2014								
Market	0.61	[60.34]	0.81	[56.18]	-0.56	[-39.22]		
Bonds	0.16	[7.32]	-0.34	[-10.90]	0.58	[18.53]		
Intercept	19.1	[3.50]	-39.4	[-5.09]	-14.8	[-1.92]	27.5	
Difference							-42.3	[p<0.001]
R-Squared								0.89

Table 2. Summary Statistics: CRSP Data and Compustat Data. Leverage ratios, asset beta and risk, and capital structure determinants, 1980 to 2014. We divide firms into profitable and unprofitable. A firm is defined as profitable if it has earnings before interest and taxes (Compustat = EBITDA) greater than zero. Variable definitions are in Appendix 1. There are 974,470 observations in 50 industries across 420 months.

	Profitable Firms			*Unprofitable Firms*		
	Avg N	**Mean**	**SD**	**Avg N**	**Mean**	**SD**
Book Leverage, Gross (%)	2,066	32.7	25.6	255	30.1	33.1
Market Leverage, Gross (%)	2,066	26.8	24.5	255	21.5	25.8
Book Leverage, Net (%)	2,066	21.3	33.4	255	12.9	41.7
Market Leverage, Net (%)	2,066	18.4	29.2	255	8.9	31.6
Asset Beta	2,066	0.71	0.54	255	0.89	0.81
Upside Asset Beta	2,066	0.58	0.56	255	0.58	0.77
Downside Asset Beta	2,066	0.83	0.61	255	1.15	0.99
Industry Upside Asset Beta	2,066	0.79	0.30	255	0.88	0.33
Industry Downside Asset Beta	2,066	0.84	0.30	255	0.93	0.32
Upside Equity Beta	2,066	0.66	0.52	255	0.53	0.60
Downside Equity Beta	2,066	0.96	0.49	255	1.06	0.62
Pre-Interest, Marginal Tax Rate (%)	2,066	33.4	10.3	255	14.0	14.0
Fixed Assets Ratio (%)	2,066	32.4	23.6	255	24.3	22.4
Profitability (%)	2,066	9.7	7.6	255	-21.5	20.4
Market-to-Book Assets	2,066	1.9	1.9	255	3.1	3.9
Log(Assets)	2,066	5.7	2.2	255	3.4	1.8
Asset Growth (%)	2,066	13.8	29.6	255	3.3	46.2

Table 3. Correlations: CRSP Data and Compustat Data. Leverage ratios, asset beta and risk, and capital structure determinants, 1980-2014. Variable definitions are in Appendix 1. There are 974,470 observations in 50 industries across 420 months.

Panel A. Leverage Ratios

	Book Leverage		*Market Leverage*	
	Gross	Net	Gross	Net
Book Leverage, Gross (%)	1.00			
Market Leverage, Gross (%)	0.78	1.00		
Book Leverage, Net (%)	0.93	0.77	1.00	
Market Leverage, Net (%)	0.78	0.93	0.86	1.00

Panel B. Leverage Determinants

	Own Asset Risk				*Industry Asset Risk*			*Own Equity Risk*		
	Beta	Up	Down	SD	Up	Down	SD	Up	Down	SD
Asset Beta	1.00									
Upside Asset Beta	0.87	1.00								
Downside Asset Beta	0.93	0.65	1.00							
Asset Risk (%)	0.58	0.34	0.66	1.00						
Industry Upside Asset Beta	0.37	0.33	0.35	0.29	1.00					
Industry Downside Asset Beta	0.34	0.27	0.35	0.30	0.91	1.00				
Industry Asset Risk (%)	0.29	0.22	0.29	0.34	0.75	0.83	1.00			
Upside Equity Beta	0.62	0.82	0.37	-0.01	0.23	0.17	0.10	1.00		
Downside Equity Beta	0.63	0.45	0.69	0.18	0.26	0.28	0.18	0.53	1.00	
Risk (%)	0.17	0.02	0.25	0.61	0.23	0.27	0.33	-0.03	0.28	1.00
Pre-Int. Mgl. Tax Rate (%)	-0.07	0.01	-0.12	-0.37	-0.12	-0.12	-0.16	0.09	-0.03	-0.47
Fixed Assets Ratio (%)	-0.22	-0.16	-0.23	-0.25	-0.28	-0.25	-0.24	-0.06	-0.10	-0.15
Profitability (%)	-0.02	0.06	-0.07	-0.30	-0.06	-0.06	-0.09	0.09	-0.05	-0.42
Market-to-Book Assets	0.19	0.15	0.19	0.18	0.18	0.18	0.17	0.10	0.14	0.18
Log(Assets)	0.12	0.28	-0.02	-0.41	-0.11	-0.15	-0.12	0.47	0.16	-0.51
Asset Growth (%)	0.07	0.05	0.08	0.03	0.03	0.05	0.03	0.05	0.10	0.04

Table 4. Summary Statistics for the Subsample of Profitable Firms: CRSP Data and Compustat Data. Leverage ratios, asset beta and risk, and capital structure determinants, 1980-2014. We divide the sample of profitable CRSP-Computstat firms into six groups, according to gross book leverage (in Panels A and B) and according to pre-interest marginal tax rate (across three pairs of columns). A firm is defined as profitable if it has earnings before interest and taxes (Compustat = EBITDA) greater than zero. The marginal tax rate is from John Graham, computed using the methodology of Graham and Mills (2008). Variable definitions are in Appendix 1.

	Tax Rates					
	Avg N	**MTR<5%**	**Avg N**	**Middle**	**Avg N**	**MTR>30%**
Panel A. Low Leverage, <5% Gross Book Leverage						
Book Leverage, Gross (%)	17	0.7	55	0.9	283	1.0
Market Leverage, Gross (%)	17	0.7	55	0.8	283	0.7
Book Leverage, Net (%)	17	-20.4	55	-19.9	283	-20.0
Market Leverage, Net (%)	17	-16.1	55	-17.0	283	-13.9
Asset Beta	17	1.22	55	1.14	283	1.05
Upside Asset Beta	17	0.89	55	0.83	283	0.85
Downside Asset Beta	17	1.50	55	1.40	283	1.21
Industry Upside Asset Beta	17	0.94	55	0.94	283	0.91
Industry Downside Asset Beta	17	0.99	55	0.98	283	0.95
Upside Equity Beta	17	0.62	55	0.58	283	0.70
Downside Equity Beta	17	1.04	55	0.97	283	0.96
Pre-Interest, Marginal Tax Rate (%)	17	1.9	55	17.8	283	36.6
Fixed Assets Ratio (%)	17	22.0	55	21.6	283	22.0
Profitability (%)	17	4.8	55	6.4	283	14.7
Market-to-Book Assets	17	2.82	55	2.13	283	2.98
Log Assets	17	4.06	55	3.97	283	4.86
Asset Growth (%)	17	17.6	55	11.3	283	15.1
Panel B. High Leverage, >50% Gross Book Leverage						
Book Leverage, Gross (%)	19	75.9	78	74.3	371	67.9
Market Leverage, Gross (%)	19	57.7	78	58.2	371	54.8
Book Leverage, Net (%)	19	71.1	78	69.8	371	63.1
Market Leverage, Net (%)	19	54.1	78	54.3	371	50.9
Asset Beta	19	0.37	78	0.37	371	0.41
Upside Asset Beta	19	0.25	78	0.26	371	0.33
Downside Asset Beta	19	0.48	78	0.45	371	0.48
Industry Upside Asset Beta	19	0.75	78	0.73	371	0.68
Industry Downside Asset Beta	19	0.81	78	0.79	371	0.73
Upside Equity Beta	19	0.54	78	0.55	371	0.65
Downside Equity Beta	19	1.03	78	0.97	371	0.97
Pre-Interest, Marginal Tax Rate (%)	19	2.2	78	17.9	371	37.1
Fixed Assets Ratio (%)	19	37.3	78	37.2	371	35.3
Profitability (%)	19	2.1	78	4.2	371	7.7
Market-to-Book Assets	19	1.96	78	1.74	371	1.58
Log Assets	19	5.34	78	5.29	371	6.37
Asset Growth (%)	19	17.6	78	7.5	371	17.0

Table 5. Capital Structure and Asset Risk, 1980-2014. Tobit regressions of gross book leverage on capital structure determinants. Gross leverage ratio is defined as long-term debt (DLTT) plus notes payable (NP) divided by long-term debt plus notes payable plus book equity. Book equity is computed in the same way as in Ken French's data library. Regressions labeled "Own Risk Measures" use firm measures of asset beta and asset risk. Regressions labeled "Industry Risk Measures" use matched Fama-French industry measures of asset beta and asset risk. Other variable definitions are in Appendix 1.

	Base		*Own Risk Measures*				*Industry Risk Measures*			
	Coef	**[t]**	**Coef**	**[t]**	**Coef**	**[t]**	**Coef**	**[t]**	**Coef**	**[t]**
Panel A. Asset Beta										
Asset Beta			-11.6	[-13.0]	-12.6	[-10.6]	-15.8	[-4.5]	-9.4	[-2.5]
Asset Risk (%)			-2.74	[-16.7]	-2.65	[-13.3]	-2.39	[-2.6]	-2.44	[-2.4]
Pre-Interest										
Marginal Tax Rate (%)	0.11	[2.4]			-0.11	[-3.0]			0.06	[1.4]
Fixed Assets Ratio (%)	0.19	[4.1]			0.05	[1.6]			0.14	[3.5]
Profitability (%)	-0.40	[-8.2]			-0.46	[-13.5]			-0.39	[-8.2]
Market-to-Book Assets	-1.4	[-5.7]			-0.3	[-1.3]			-1.1	[-5.0]
Log Assets	2.8	[8.8]			2.0	[6.4]			2.6	[10.3]
Asset Growth (%)	0.04	[4.4]			0.06	[9.4]			0.04	[4.7]
Two-Way Clustering		Yes		Yes		Yes		Yes		Yes
Industries		50		50		50		50		50
Months		420		420		420		420		420
N (000)		974		974		974		974		974
Panel B. Upside and Downside Asset Beta										
Upside Asset Beta			-6.4	[-10.7]	-8.1	[-11.7]	-14.7	[-5.2]	-12.7	[-3.9]
Downside Asset Beta			-8.2	[-12.4]	-7.5	[-12.1]	-0.3	[-0.1]	5.1	[1.5]
Upside Asset Risk (%)			-1.71	[-4.7]	-0.69	[-1.4]	-3.55	[-1.0]	4.84	[1.1]
Downside Asset Risk (%)			-3.15	[-6.3]	-4.06	[-8.2]	-3.07	[-0.9]	-12.22	[-3.0]
Controls		Yes		Yes		Yes		Yes		Yes
Two-Way Clustering		Yes		Yes		Yes		Yes		Yes
Industries		50		50		50		50		50
Months		420		420		420		420		420
N (000)		974		974		974		974		974

Table 6. Alternate Leverage Ratios and Equity Beta, 1980-2014. Tobit regressions of leverage on capital structure determinants. We repeat the final regression of Table 7 using four different measures of leverage. Net leverage ratios deduct cash and equivalents from debt. Market leverage ratios replace book equity with market capitalization, equal to price times shares outstanding from CRSP. Panel B replaces asset measures of beta and risk with equity measures of beta and risk.

	Gross Leverage (%)				*Net Leverage (%)*			
	Book		*Market*		*Book*		*Market*	
	Coef	**[t]**	**Coef**	**[t]**	**Coef**	**[t]**	**Coef**	**[t]**
Panel A. Upside and Downside Asset Beta								
Upside Asset Beta	-8.1	[-11.7]	-8.4	[-12.0]	-13.1	[-11.3]	-12.6	[-13.7]
Downside Asset Beta	-7.5	[-12.1]	-8.0	[-13.3]	-16.5	[-12.9]	-16.3	[-15.5]
Upside Asset Risk (%)	-0.69	[-1.4]	-1.05	[-2.7]	-3.99	[-7.8]	-4.50	[-10.4]
Downside Asset Risk (%)	-4.06	[-8.2]	-3.36	[-7.9]	-8.70	[-12.9]	-7.86	[-15.9]
Controls		Yes		Yes		Yes		Yes
Two-Way Clustering		Yes		Yes		Yes		Yes
Industries		50		50		50		50
Months		420		420		420		420
N (000)		974		974		974		974
Panel B. Upside and Downside Equity Beta								
Upside Equity Beta	-7.3	[-7.4]	-8.1	[-9.6]	-10.3	[-6.4]	-10.6	[-8.1]
Downside Equity Beta	1.5	[1.5]	0.5	[0.7]	0.5	[0.4]	-0.1	[-0.1]
Upside Equity Risk (%)	5.80	[9.0]	4.84	[8.5]	6.61	[7.9]	5.51	[8.1]
Downside Equity Risk (%)	-0.99	[-1.5]	-0.45	[-0.8]	-1.03	[-1.3]	-0.48	[-0.8]
Controls		Yes		Yes		Yes		Yes
Two-Way Clustering		Yes		Yes		Yes		Yes
Industries		50		50		50		50
Months		420		420		420		420
N (000)		974		974		974		974

Appendix 1. Variable Definitions. All variables are Winsorized at 1% and 99% as measured across the whole sample.

Asset Beta Equity Beta times one minus net market leverage.

Asset Growth The annual change in total assets (AT) divided by total assets one year ago, in percentage terms.

Asset Risk (%) Equity Risk times one minus market leverage, net.

Book Equity Shareholder's equity minus preferred stock plus deferred taxes. Shareholder's equity (SEQ) or the sum of common equity (CEQ) plus preferred stock (PSTK) if shareholder's equity is missing or total assets (AT) minus total liabilities (LT) if common equity is missing. Preferred stock is equal to the redemption value of preferred stock (PSTKRV) or the liquidating value of preferred stock (PSTKL) or total preferred stock (PSTK) in that order and set to zero if still missing. Deferred taxes are equal to deferred tax and investment tax credit (TXDITC) or balance sheet deferred tax (TXDB) in that order and zero if missing.

Book Leverage, Gross (%) The sum of total long-term debt (COMPUSTAT = DLTT) and notes payable (NP) divided by the sum of total long-term debt and notes payable and book equity, in percentage terms.

Book Leverage, Net (%) The sum of total long-term debt (COMPUSTAT = DLTT) and notes payable (NP) less cash and equivalents (CHE) divided by the sum of total long-term debt and notes payable and book equity less cash and equivalents, in percentage terms.

Downside Asset Beta Downside Equity Beta times one minus net market leverage.

Downside Asset Risk (%) Downside Equity Risk times one minus market leverage, net.

Downside Equity Beta Market beta computed from CRSP returns (RET) net of Treasury bill returns (YLDMAT) from CRSP regressed on the value-weighted market return (VWRET), also net of the Treasury bill return, times an indicator variable when the realized market return is positive and the value-weighted market return times an indicator variable when the realized market return is negative, using three-day overlapping return windows. We require at least 750 overlapping windows of returns and use at most five years of returns. The downside beta is the coefficient on negative market returns.

Downside Equity Risk (%) Standard deviation of CRSP returns (RET) net of Treasury bill returns (YLDMAT), in percentage terms, conditional on the CRSP return (RET) net of the Treasury bill return being negative.

Equity Beta Market beta computed from CRSP returns (RET) net of Treasury bill returns (YLDMAT) from CRSP regressed on the value-weighted market return (VWRET), also net of the Treasury bill return, using three-day overlapping return windows. We require at least 750 overlapping windows of returns and use at most five years of returns.

Equity Risk (%) Standard deviation of CRSP returns (RET) net of Treasury bill returns (YLDMAT), in percentage terms.

Fixed Assets Ratio (%) Plant, property, and equipment, net (PPENT) divided by total assets (AT), in percentage terms.

Industry Asset Beta Market equity weighted average asset beta, computed for each Fama-French industry classification. Market equity is equal to price (PRC) times shares outstanding (CRSP) from CRSP. The 49 industry classifications are defined in Ken French's data library, with unclassified firms comprising a 50th group.

Industry Asset Risk (%) Market equity weighted average asset risk, computed for each Fama-French industry classification. Market equity is equal to price (PRC) times shares outstanding (CRSP) from CRSP. The 49 industry classifications are defined in Ken French's data library, with unclassified firms comprising a 50th group.

Log Assets The natural log of total assets (AT).

Market-to-Book Assets Sum of total long-term debt (COMPUSTAT = DLTT) and notes payable (NP) and market equity divided by the sum of total long-term debt and notes payable and book equity. Market equity is equal to price (PRC) times shares outstanding (CRSP) from CRSP.

Market Leverage, Gross (%) The sum of total long-term debt (COMPUSTAT = DLTT) and notes payable (NP) divided by the sum of total long-term debt and notes payable and market equity. Market equity is equal to price (PRC) times shares outstanding (CRSP) from CRSP, in percentage terms.

Market Leverage, Net (%) The sum of total long-term debt (COMPUSTAT = DLTT) and notes payable (NP) less cash and equivalents (CHE) divided by the sum of total long-term debt and notes payable and market equity less cash and equivalents. Market equity is equal to price (PRC) times shares outstanding (CRSP) from CRSP, in percentage terms.

Pre-Interest, Marginal Tax Rate (%) John Graham provided estimates of the pre-interest marginal tax rate, computed using the methodology of Graham and Mills (2008), in percentage terms.

Profitability (%) Earnings before interest and taxes (EBIT) divided by assets (AT), in percentage terms.

Upside Asset Beta Upside Equity Beta times one minus net market leverage.

Upside Asset Risk (%) Upside Equity Risk times one minus market leverage, net.

Upside Equity Beta See Downside Beta. The upside beta is the coefficient on positive market returns.

Upside Equity Risk (%) Standard deviation of CRSP returns (RET) net of Treasury bill returns (YLDMAT), in percentage terms, conditional on the CRSP return (RET) net of the Treasury bill return being positive.