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Strategic Risk Shifting and the Idiosyncratic Volatility Puzzle: An Empirical Investigation

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high idiosyncratic volatility. The second is conditional on the state of the aggregate economy: equity holders prefer to make investments with high idiosyncratic risk when the market is in a bad aggregate state. Intuitively, equity holders of distressed firms do not want to sink with the market and want to strategically increase idiosyncratic risk in the hope that these "idiosyncratic investments" might generate *positive* cash flows to offset the large *negative* shocks from the market. In other words, equity holders increase idiosyncratic risk to hedge against a bad market and market risk.[2] Hence, when the market switches to the bad state, a greater increment in the idiosyncratic risk provides more protection for the equity holders and makes the equity less sensitive to the market risk.

Our third and fourth predictions relate to the implications of the risk-shifting behavior for the equity beta and the stock returns in the framework of the conditional capital asset pricing model (CAPM). Following our second prediction that equity holders increase idiosyncratic volatility to lower their equity beta in the bad states, our third prediction states that the firm's strategic risk-shifting behavior leads to a negative relation between the equity beta and the market premium because the market risk premium is high in the bad states. Finally, in the conditional CAPM framework, because the negative covariance dominates the product of the expected equity beta and the market risk premium, our fourth prediction states that firms with a high level of idiosyncratic volatility receive low returns on average.

We find strong empirical support for the four predictions. Using firm-level panel regressions, we find that our profitability proxy, return on assets (RoA), is associated with the firm's future risk taking. This negative association shows that equity holders increase their idiosyncratic risk taking when their firm's profitability declines, providing support for the notion of risk shifting. To ensure that risk shifting is one of the important, sufficient conditions for the changes in idiosyncratic volatility,[3] we use two composite indexes: the *o*-score (Ohlson 1980) and the default probability of Merton (1974). The first proxy relies on a historical estimation of the relative weights of other accounting variables, and the second is calculated from the option-based model. The second proxy is particularly suitable for our study because our theoretical predictions are developed from the option-based model as well. We demonstrate that equity holders are more likely to take on investments with high idiosyncratic risk when their firms are in distress. Moreover, we employ institutional holdings to proxy for the effective monitoring of management. Low institutional holdings imply less active monitoring and severer agency conflicts (Shleifer and Vishny 1986). We find that, when profitability declines, management increases idiosyncratic risk more because it is monitored less by institutional block holders.

In examining our second prediction, that the idiosyncratic risk is higher in bad aggregate states, we use the National Bureau of Economic Research (NBER) recession dates to proxy for bad states. We find that idiosyncratic volatility increases during these times. This finding is in line with recent findings by Bloom (2009), Herskovic et al. (2015), and Bartram et al. (2016). Herskovic et al. (2015) find that the average volatilities of idiosyncratic *cash flow* and stock return residuals are high in recessions. Additionally, Bartram et al. (2016) have confirmed that both idiosyncratic cash flow volatility and return volatility increase with market risk when the market is in a bad state.

Our results still hold when we use different measures of idiosyncratic risk, such as idiosyncratic asset risk and cash flow risk, and use a different measure of operating performance, return on equity (RoE). To our knowledge, we are the first to demonstrate that the negative association between profitability and idiosyncratic risk is much more significant among distressed firms and during times of recession.

The strategically increased idiosyncratic volatility consequently affects the equity risk and returns. To verify our third and fourth predictions, we follow Lewellen and Nagel (2006), estimate the conditional monthly equity beta, and examine its covariance with the market risk premium. We empirically show that the time-varying equity beta is negatively correlated with the market return for the firms with high idiosyncratic volatility. The negative covariance among those firms dominates their levered equity beta, generating low stock returns and negative CAPM alphas for them. To our knowledge, our work is the first to provide a risk-based explanation for the low stock returns and CAPM alphas in firms with high idiosyncratic volatility.

Our paper relates to a few recent papers that examine the idiosyncratic cash flow risk, growth options, and stock returns.[4] Among them, Babenko et al. (2016) provide a rationale for the idiosyncratic risk puzzle through the lens of a conditional one-factor model in which idiosyncratic risk affects equity betas. Complementing Babenko et al. (2016), our work shows how equity holders' strategic actions generate the endogenous idiosyncratic risk over the business cycle. That is, the equity holders of a distressed firm increase the idiosyncratic cash flow risk to reduce the equity beta, particularly in recessions when the market risk premium is high.

The risk-shifting behavior of corporations has been studied extensively in previous research. A nonexclusive list includes Leland (1998), Ericsson (2000), Hennessy and Tserlukevich (2008), Cheng and Milbradt (2012), Favara et al. (2017), and Piskorski and Westerfield (2015). Empirically, Eisdorfer (2008) was the first to use a large sample of firms to identify distressed firms' risk-shifting behavior. He identifies a positive relation between capital investments and uncertainty among distressed firms, which is empirically proxied by stock return volatility. Differently to Eisdorfer (2008), we emphasize the *idiosyncratic* risk taking in response to cross-sectional financial status and aggregate economic states in this paper.

Our paper belongs to an emerging literature that examines the implications of agency conflicts for asset prices. Davydenko and Strebulaev (2007) demonstrate that strategic default decisions made by equity holders have an adverse effect on bond prices. Albuquerue and Wang (2008) examine the impacts of corporate governance on stock valuation and show that firms in countries with weaker investor protection have more incentives to overinvest, lower Tobin's q values, and larger risk premia. Carlson and Lazrak (2010) show that managerial stock compensation induces risk-shifting behavior that helps explain the rates of credit default swaps and leverage choices. Huang et al. (2011) find that mutual funds that increase risk perform worse than funds with stable risk levels and conclude that agency issues might cause risk shifting by fund managers. Favara et al. (2012), Garlappi and Yan (2011), and Hackbarth et al. (2015) study the effect of equity holders' bargaining power at bankruptcy on stock returns. By studying another agency conflict, we demonstrate that the negative association between idiosyncratic volatility and the future stock return might be driven by strategic risk-shifting behavior.

Our paper is related to two contemporaneous papers that connect operating profitability with cross-sectional equity returns. Hou et al. (2015) show that an empirical q-factor model explains more than half of 80 anomalies, including the idiosyncratic volatility anomaly, but does not explicitly explain why their profitability factor determines the association between idiosyncratic volatility and future returns. Fama and French (2016, p. 92) propose a five-factor model to explain the idiosyncratic volatility puzzle and provide additional empirical evidence that "the returns of high volatility stocks behave like those of firms that are relatively unprofitable but nevertheless invest aggressively," which is indeed the manifestation of the standard risk-shifting problem whereby less profitable firms choose to invest more. Nevertheless, Fama and French (2016) do not provide an economic story to explain their finding either. We complement their study by providing a risk-shifting story to connect the aggressive investment behavior of unprofitable/distressed firms with their high-volatility but low stock returns.

The remainder of the paper proceeds as follows. We propose our four predictions in Section 2. Data and empirical measures are described in Section 3. Section 4 contains the empirical results. Section 5 concludes the paper. We present a simple option-based model in the appendix and an extended model that incorporates the countercyclical market premium in the online appendix.

2. Empirical Predictions

We develop a simple model to generate four testable

Risk shifting is different from risk taking.[5] When investing in high-risk investments and suffering a loss, equity holders in a distressed firm do not have to pay

because of their

in a distressed firm do not bear any losses themselves and, instead, shift the increased risk to the debt holders. As a result, high asset/cash flow risk does not guarantee high *equity* risk and, instead, might even lower the equity risk for distressed firms.

More importantly, asset and cash flow risk can be decomposed into systematic risk and idiosyncratic risk components. If the

riorating, equity holders in a distressed firm who anticipate a large, negative shock and do not want to sink with the market prefer to invest in projects that are different from, or idiosyncratic to, the market in the hope that these idiosyncratic investments might generate flows to offset the shocks from the deteriorating market. In other words, the action of taking on additional idiosyncratic asset risk is similar to a hedge against the market risk, reducing the equity holders' exposure to the market risk. Therefore, the increased idiosyncratic asset or cash flow risk implies a decrease in the *systematic equity* risk for distressed firms.

The simple model that captures the aforementioned risk-shifting notion can be described as follows. There are two levels of business risk. In the low risk level $l = L$, a fi finances the investments with equity and debt. The installed investments produce cash flows X_t, which the firm uses to pay taxes at a rate τ to the government and coupon payments c to the debt holders. The dividend received by the equity holders is the entire cash flow X_t, net of the coupon payments c to the debt holders and net of the tax payments. If the cash flows X_t decline to a low threshold X_r, the firm chooses to invest in high-risk assets and enters a high risk level, hoping that the increased cash flow volatility might lead to a cash flow windfall, which might save the firm. At the risk-shifting threshold X_r, given a proportional cost $\eta \geq 0$, the equity holders choose an *optimal* increment in cash flow volatility, ϵ^*, to maximize the equity value. If this corrective action does not save the firm, the equity holders decide to go into bankruptcy at the threshold X_d. Bankruptcy leads to immediate liquidation, in which equity holders receive nothing.

With the simple model, we have the following prediction 1 that states how equity holders determine the amount by which they increase the idiosyncratic asset risk in response to the operating performance of their own firm.

Prediction 1. *Equity holders in a distressed firm with a lower expected growth rate in cash flows or operating profits choose a greater increment in the idiosyncratic cash flow volatility.*

The amount of the increase in idiosyncratic risk chosen by the equity holders depends on the severity of the financial status. Equity holders who expect a lower growth rate choose to take on more idiosyncratic risk. Intuitively, the low expected cash flow growth implies a low likelihood of the firm surviving, inducing equity holders to gamble more. Hence, the lower the cash flow rate, the greater the taking of idiosyncratic risk will be. In Section A.5, we use a simple model to numerically illustrate that equity holders choose a *greater* optimal amount of idiosyncratic risk taking in response to a lower asset return.

Prediction 2 connects the status of the aggregate economy with corporate risk-shifting behavior.

Prediction 2. *Distressed firms strategically increase idiosyncratic risk more in bad aggregate states, when the market risk premium is high, than in good aggregate states, when the market risk premium is low.*

This prediction is similar to the first because bad aggregate states adversely affect firms' performance. Whereas the first prediction relies on the *cross-sectional* difference in the expected cash flow rate to generate cross-sectionally different risk-taking decisions, this prediction relies on the time-varying market risk premium to generate time-varying risk-shifting decisions over the business cycle. Intuitively, in addition to the already decreased cash flow level, the high market risk premium in the bad states increases the discount rate and further decreases the firm value, generating an even greater incentive to shift risk. Thus, the increased market risk premium in the bad states induces the distressed firms to take on more idiosyncratic investments, which, in turn, help equity holders to hedge against the market risk in the bad states. Our numerical example in the appendix confirms this insight.

2.2. Stock Returns in the Framework of the Conditional CAPM

The option-based framework and the CAPM are not mutually exclusive. Instead, they are connected. The earliest contingent-claims (or option-based) models can be dated back to the European options model of Merton (1974). By assuming the underlying asset value is driven by a single market factor, Galai and Masulis (1976) were the first to *theoretically* link the options model (Merton 1974) with the standard CAPM with a *constant* market risk premium.[6] We extend the literature and study the effect of *strategic* risk shifting on the stock returns in the conditional CAPM.

Proposition 1. *When the firm is alive, its conditional excess return of equity* r_t^{ex} *is*

$$r_t^{ex} = \mathbf{E}_{t-1}\left[r_t^E\right] - rdt = \mathbf{E}\left[\gamma_{l,t}\beta\lambda dt\right] = \mathbf{E}_{t-1}\left[\beta_t^E \lambda_t dt\right], \quad (1)$$

where λ_t *is the time-varying market risk premium and* β_t^E *is the time-varying equity beta*

$$\beta_t^E = \gamma_l \beta = \frac{\partial E_{l,t}/E_{l,t}}{\partial X_t/X_t}\beta = \frac{\partial E_{l,t}/E_{l,t}}{\partial V_{l,t}/V_{l,t}}\beta, \quad (2)$$

where γ_l *is the stock-cash flow elasticity,* β *is the cash flow or asset beta, and* $V_{l,t}$ *and* $E_{l,t}$ *are the asset value and equity value with a risk level* l *at time* t.

Proof. See the appendix.

In the framework of conditional CAPM, Equation (1) states that the expected excess stock return is simply the *market* risk premium λ times the equity beta $\beta_{l,t}^E$ for the firms with a level of idiosyncratic risk l. We model the idiosyncratic volatility effect in the conditional CAPM that allows the time-varying levered beta and countercyclical market risk premium. The levered beta in our model effectively captures the size and value effects because Fama and French (1996) argue that size and value factors are indeed the conditioning variables in the conditional CAPM.[7]

Although the financial leverage and levered equity betas help to account for the size and value premia in the conditional CAPM, what is left unexplained is the idiosyncratic volatility effect. We introduce the strategic risk shifting into this framework and show that, because equity holders time the market to change the level of idiosyncratic risk, the equity betas and market risk premium negatively covary, which, in turn, generates the low returns in the firms with high idiosyncratic volatility.

Consider a special case in which the market risk premium is constant and *beta* = 1; we have the following proposition for levered equity betas.

Proposition 2. *When the firm is distressed and has a high level of idiosyncratic volatility, $l = H$ for $X_t > X_r$, and the firm's equity beta is*[8]

$$\beta^E_{H,t} = 1 + \underbrace{\frac{c/r(1-\tau)}{E_{H,t}}}_{\text{Leverage}} \underbrace{-(1-\omega_{H,1})\frac{(c/r - V_{H,d})}{E_{H,t}}\left(\frac{X_t}{X_d}\right)^{\omega_{H,1}}(1-\tau)}_{\text{American Put Option of Delaying Bankruptcy (+)}}, \quad (3)$$

where r is the risk-free rate, $V_{H,d}$ is the asset value of the high-volatility firm at the bankruptcy threshold X_d, $E_{H,t}$ is equity value of the high-volatility firm, and $\omega_{H,1}$ is the negative root of a characteristic function. They are defined in the appendix.

When the firm is healthy and has a low level of idiosyncratic volatility, $l = L$ for $X_r > X_t > X_D$, and the firm's equity beta is

$$\beta^E_{L,t} = 1 + \underbrace{\frac{c/r(1-\tau)}{E_{L,t}}}_{\text{Leverage}} + \underbrace{\frac{V_{L,r} - V_{H,r} + \eta\epsilon^2 V_{H,r}}{E_{L,t}}\left(\frac{X_t}{X_r}\right)^{\omega_{L,1}}(1-\tau)(1-\omega_{L,1})}_{\text{Option of Increasing Risk (+)}} \underbrace{-\frac{c/r - V_{H,d}}{E_{L,t}}\left(\frac{X_r}{X_d}\right)^{\omega_{H,1}}\left(\frac{X_t}{X_r}\right)^{\omega_{L,1}}(1-\tau)(1-\omega_{L,1})}_{\text{American Put Option of Delaying Bankruptcy (+)}}, \quad (4)$$

where $V_{L,r}$ and $V_{H,r}$ are the asset values of the low- and high-volatility firms at the risk-shifting threshold X_r, $E_{H,t}$ is the equity value of the high-volatility firm, and $\omega_{L,1}$ and $\omega_{H,1}$ are the negative roots of a characteristic function. They are defined in the appendix.

Proof. See the appendix.

After the risk shifting, the equity beta in Equation (3) consists of three components. The first is normalized to one. The second is related to financial leverage as c/r can be regarded as risk-free equivalent debt. Not surprisingly, the equity beta i.4(b(suv)6h6st)-4.4(invely-320.as)soitted twith]TJETBT9.9626009.962645.41189293.84362Tm[(t)h idiosyncratic risk more in response to the increased market risk premium.[11]

Following prediction 3, the next prediction states the unconditional expected stock returns and CAPM alphas that are implied by the conditional CAPM.

Prediction 4 states that, for firms that have strategically increased their idiosyncratic volatility to a high level, if the negative covariance between the equity beta and the market risk premium dominates the product of the expected equity beta and the expected market risk premium, that is, $\mathbf{E}[\beta_t^E]\mathbf{E}[\lambda_t]dt + \mathbf{cov}(\beta_t^E, \lambda_t)dt < 0$, those firms are expected to earn low stock returns and CAPM alphas.

Lewellen and Nagel (2006) show that, if the conditional CAPM holds, the unconditional expected excess return is

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return volatility. That is, $v_{i,t}^{A} = (1 - Lev_{i,t})v_{i,t}^{E}$, where $lev_{i,t}$ is the financial leverage. This measure allows us to keep the advantage of high-frequency data and has frequently been used in the literature. For example, Schaefer and Strebulaev (2008) construct the asset volatility to study the predictability of the equity–debt hedging ratio. Choi (2013) constructs a similar measure to examine the value premium. Finally, Chen et al. (2013) create asset systematic risk to study its implications for debt maturity.

Our third measure of risk taking is the annualized standard deviation of 12 quarterly RoA residuals. As argued in Irvine and Pontiff (2009), increases in idiosyncratic return volatility can be attributed to increases in the idiosyncratic volatility of fundamental cash flows. To get rid of market-wide fluctuations in the RoA, we first obtain the firm-specific RoA, $u_{i,t}^{RoA}$, by regressing the firm-level RoA on the market-level RoA for the whole sample:

$$RoA_{i,t} = a_i + b_i RoA_{M,t} + u_{i,t}^{RoA}, \tag{8}$$

where $RoA_{M,t}$ is the market-level RoA proxied by the average of the RoA values, weighted with the book assets, across all firms at quarter t. We then compute $v_{i,t}^{RoA}$ as the standard deviation of the residual RoA from the next 12 future quarters.

3.3. Distress Indicators

Taking risk does not necessarily mean shifting risk—just doing so when firms are in distress as we discussed in relation to our first prediction. To ensure that the negative relation between the RoA and risk taking is driven by the risk-shifting mechanism, we use three conditional variables to proxy for the firm's distress status. The three conditional variables indirectly indicate that the firms are more likely to shift risk. The use of indicator variables allows a better and clearer interpretation of the nonlinear risk-shifting effect.

The first condition is that firms have a high o-score, which is a composite index of a firm's financial status, estimated and proposed by Ohlson (1980). We calculate the o-score as follows:

$$\begin{aligned} o\text{-score}_{i,t} = {} & -1.32 - 0.407\ln(TA_{i,t}) + 6.03\frac{TL_{i,t}}{TA_{i,t}} \\ & - 1.43\frac{WC_{i,t}}{TA_{i,t}} + 0.076\frac{CL_{i,t}}{CA_{i,t}} \\ & - 1.72I\big(TL_{i,t} > TA_{i,t}\big) - 2.37\frac{NI_{i,t}}{TA_{i,t}} \\ & - 1.830.18\frac{FFO_{i,t}}{TL_{i,t}} \\ & + 0.285I(\text{continuous two-quarter net loss}) \\ & - 0.521 \text{―――――} \end{aligned}$$

Arnold et al. (2017) find that distressed firms finance their investments with asset sales. Although Arnold et al. (2017) do not examine the resulting change in the riskiness after distressed asset sales, we complement their results and examine whether the idiosyncratic return volatility increases after "distressed" asset sales. Following their study, we calculate *AssetSale* as the sold assets (Item SPPE) divided by the assets in the last quarter (item PPENT).

3.5. Control Variables

When testing the first two predictions, we control for firm size, growth opportunities, and financial leverage. We use the logarithmic value of assets (Compustat item ATQ), *log*(*BA*), to proxy for the firm size; book-to-market assets, *MABA*, for the growth opportunities; and market leverage, *MktLev*, for the financial leverage. Market leverage, *MktLev*, is measured as the ratio of total debt to the total market asset value, which is the sum of total debt (item DLCQ plus item DLTTQ) and the market value of equity (PRCCQ times CSHOQ). In addition, although we assume managers act on behalf of equity holders and do not model their risk-taking incentives explicitly, we follow Hirshleifer et al. (2012) and control for managerial compensation because stock-based compensation has an effect on managerial risk taking. Using Standard and Poor's ExecuComp database, we calculate delta and vega using the one-year approximation method of Core and Guay (1999) and take the natural logarithms of these two variables. *Delta* is defined as the dollar change in a CEO's stock and option portfolio given a 1% change in stock price, which measures the managerial incentive to increase the stock price. *Vega* is the dollar change in a CEO's option holdings in response to a 1% change in stock return volatility, which measures the risk-taking incentives generated by the managerial stock option holdings.

When testing the third prediction on the association between the equity beta and the market risk premium, we follow the literature and control for monthly contemporaneous factor loadings and lagged firm characteristics in our regressions. Firm characteristics include size (the natural logarithm of market equity, *ME*), book-to-market equity (*BE*/*ME*), market leverage (*MktLev*), and the previous six months' cumulative stock return (*PreRets*).

Finally, we winsorize all the variables at the top and bottom 1% to reduce the impact of outliers and lessen the power of potential errors.

4. Empirical Results

In this section, we start by providing summary statistics. Then, we test the first two predictions on the risk-shifting behavior when the firm is in distress or the aggregate economy is in a bad state. Lastly, we proceed to assess the next two predictions on the equity beta, returns and CAPM alphas.

4.1. Summary Statistics

Table 1 presents summary statistics for all the key and control variables we use in this study. We report the number of observations, minimums, 25th percentiles (P25), means, medians, 75th percentiles (P75), maximums, standard deviations, and the first autocorrelation coefficients (AR(1)).

On average, our sample includes 2,797 to 3,384 firms per quarter. The annualized RoA, our proxy for profitability, has a mean of 10.00% and a standard deviation of 20.87%. RoA is also highly persistent with an autocorrelation of 0.96. Similarly, the RoE, the alternative proxy for profitability, has a smaller mean of 4.36% and a standard deviation of 20.18%. For the three proxies for idiosyncratic risk, the mean of the annualized idiosyncratic return volatility $\nu^E_{i,t}$ computed over three months is 55.95%; that of idiosyncratic asset volatility $\nu^A_{i,t}$ is 41.64%; and the mean of the volatility of 12-quarter RoA, $\nu^R oA_{i,t}$, is 11.81%. All three proxies are highly persistent as indicated by their AR(1) coefficients, which are at least 0.69.

We have three firm-level conditioning variables. The *o-score*, our first proxy for financial status, ranges from −92.45 to 245.35. The expected default probability (*DefProb*) of Merton (1974) is 6%, which is largely consistent with the actual default probability of 5% among U.S. firms. The third conditioning variable is the percentage of large institutional investors, which has a mean of 37% and a median of 31%. Moreover, asset sales (*AssetSale*), the potential cause of the idiosyncratic risk, are small and have a mean of 0.88%. As for the control variables, the average asset size is 139.77 ($e^{4.94}$) million dollars. Market-to-book assets (*MABA*) and market leverage (*MktLev*) have means of 1.90 and 0.24, respectively, and are both highly persistent.

Panel B presents the monthly data we use to test the third prediction on the relation between the equity beta and the market risk premium. The annualized monthly stock return has an average of 15.57% and is slightly negatively serially correlated. The average annualized idiosyncratic volatility computed over one month has an average of 50.06%. The average size and book-to-market equity ratio in our monthly data are 76.71($e^{4.34}$) million dollars and 0.89, respectively, both of which are about the same as those of a median firm in the U.S. stock markets. The average firm leverage ratio is 0.26. The average annualized lagged six-month cumulative return (*PreRets*) is 15.80% with a standard deviation of 87.39%. Overall, the statistics of our main variables are largely consistent with the empirical literature.

Table 1.

RoA , (%)	2,797	–							
RoE ,t(%)	3,182	–							
$v^E_{i,t}$(%)									
v^A (%)									
$^{RoA}_{i,t}$									
$_{i,t}$									
$Def\,Prob_{i,t}$	3,382	0.00	0.00	0.06	0.00	0.00	1.00	0	0.82
$Inst_{i,}$	3,004	0.00	0.10	0.37	0.31	0.59	8.88	0	0.93
$AssetSale_{i,t}$	3,323	–							
$log(BA)_{,t}$	3,365	–							
$MABA_{i,t}$	3,213	0.43	1.03	1.90	1.37	2.08	26.05	1.63	0.92
MktLev	3,327	0.00	0.02	0.24	0.17	0.38	1.00	0	0.96
$log(1 + Delta)_{i\,t}$	3,382	0.00	0.00	0.83	0.00	0.00	13.00	2.04	0.96
$log(1 + Vega)_{i,t}$	3,382	0.00	0.00	0.59	0.00	0.00	9.25	1.51	0.97

Panel B: Monthly data

	Observations/Month	Minimums	P25	Mean	Median	P75	Maximums	Standard deviation	AR(1)
$r^E_{i,t}$(%)	3,482	−786.]4	−81.59	15.57	0.31	89.42	2904.66	68.67	−0.05
$v^E_{i,t}$(%)	3,482	2.76	26.80	50.06	40.53	61.44	662.60	36.42	0.59
[redacted]	3,482	[redacted]	2.96	4.34	[redacted]	[redacted]	11.50	0.66	1.00
[redacted]	[redacted]	[redacted]	0.41	0.89	0.68	1.08	30.99	0.51	0.95
$PreRets_{i,t}$	3,362	−166.58	−29.35	15.80	5.24	44.60	1302.37	87.39	0.80
$MktLev_{i,t}$	2,705	0.01	0.06	0.26	0.20	0.40	0.95	0.11	0.99

Notes. This table reports the number of observations, minimums, 25th percentiles (P25), means, medians, 75th percentiles (P75), maximums, standard deviations, and the first autocorrelation coefficients (AR(1)) for all the key and control variables. Panel A includes return on assets ($RoA_{i,t}$), return on equity ($RoE_{i,t}$), idiosyncratic stock return volatility ($v^E_{i,t}$), idiosyncratic volatility of assets ($v^A_{i,t}$), idiosyncratic volatility of 12-quarter RoA ($v^{RoA}_{i,t}$), *o*-score (Ohlson 1980), default probability (*Def Prob*) of Merton (1974), fraction of institutional block holders ($Inst_{i,t}$), asset sales ($Assetsales_{i,t}$), natural logarithm of assets ($\log(BA)_{i,t}$), market-to-book assets ($MABA_{i,t}$), market leverage ($MktLev_{i,t}$), and natural logarithms of delta and vega of managerial stock options. All the variables are expressed as an annual percentage wherever possible. The monthly variables in panel B include the stock return ($r^E_{i,t}$), monthly idiosyncratic stock return volatility ($v^E_{i,t}$), logarithm of market capitalization ($Size_{i,t}$), book-to-market equity ($BE/ME_{i,t}$), cumulative six-month stock returns ($PreRets_{i,t}$), and market leverage ($MktLev_{i,t}$).

Table 2 summarizes the average returns of the value-weighted stock portfolios. Panel A shows that, although the difference in the stock returns for the firms in the lowest *o*-score tercile is −6.21% per year, the difference for the firms in the top tercile is −18.42% per year. The contrast suggests that the idiosyncratic volatility puzzle is stronger in distressed firms. Similarly, in panel B, where we use Merton's default probability as the proxy for the distress status, the contrast between firms with low and high default probabilities is even stronger. Specifically, among the firms with the lowest default probabilities, the idiosyncratic volatility discount is only −6.37% per year and statistically insignificant with a *t*-statistic of −1.37. In contrast, among those with the highest default probabilities, the volatility discount is −21.63% per year with a significant *t*-statistic of −5.13.

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Risk Shifting

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low profitability ake on investments ith high idiosyncratic risk. W empirically test whether idiosyncratic risk significantly increases at quarter *t* given a decrease in $RoA_{i,t-1}$.

To examine the firms' risk-taking policy in response to changing asset values, we perform the standard panel regressions at the firm level, as follows:[17]

$$y_{i,t} = a + bRoA_{i,t-1} + cD(.)RoA_{i,t-1} + dD(.) + f\,Control_{i,t-1} + e_{i,t}, \quad (10)$$

where the dependent variable $y_{i,t}$ is the proxy of risk taking, the idiosyncratic return volatility over the next three months, $\nu^{E}_{i,t}$. To examine the asymmetric association between profitability and idiosyncratic risk taking, we include a dummy variable, $D(.)$, to identify the scenarios in which the firms are in distress or their management is subject to less monitoring from institutional holders. The indicator takes a value of one if the *o*-score of the last quarter is classified into the top tercile ($OS = 3$), if the default probability of Merton is classified into the top tercile ($Def\,Prob = 3$), if the economy of the previous month falls into an NBER recession period, or if the institutional holdings of the top five block holders are classified into the bottom tercile ($inst = 1$). Although b_t measures idiosyncratic risk taking in response to the RoA, regardless of the likelihood of risk shifting, c_t measures the additional effect when risk shifting is highly likely to occur. That is, $b_t + c_t$ captures the effect of $RoA_{i,t-1}D(.)$ on the future idiosyncratic volatility when risk shifting is more likely, that is, $D(.) = 1$. Finally, we include a vector of various control variables, $Control_{i,t-1}$ described in the previous section, such as the logarithmic value of assets, book-to-market equity, the market leverage ratio, delta and vega of managerial stock options, and standso27trr9Biandbt6(tr9Biand)-3e2.4(s).2(ndso2n(his21.3

Table 3. Profitability and Subsequent Idiosyncratic Risk Taking

	Baseline		*OS* = 3		*Def Prob* = 3		*Recession* = 1		*inst* = 1	
	Reg I	Reg II	Reg I	Reg II	Reg I	Reg II	Reg I	Reg II	Reg I	Reg II
Intercept	60.25	87.06	50.01	78.04	54.87	84.29	58.93	80.58	55.78	85.87
(*t*)	(308.01)	(36.25)	(171.76)	(36.47)	(261.65)	(34.89)	(537.27)	(63.33)	(221.46)	(34.83)
$RoA_{i,t-1}$	−0.40	−0.25	−0.18	−0.12	−0.27	−0.16	−0.41	−0.28	−0.34	−0.19
(*t*)	(−19.11)	(−19.97)	(−14.83)	(−9.93)	(−16.85)	(−13.38)	(−39.36)	(−28.77)	(−16.24)	(−15.13)
$D(.)$			24.49	17.90	13.02	4.56	14.41	12.24	11.53	4.39
(*t*)			(27.77)	(25.92)	(25.63)	(14.90)	(36.91)	(32.12)	(21.42)	(10.93)
$D(.)RoA_{i,t-1}$			−0.43	−0.39	−0.16	−0.19	−0.21	−0.20	−0.10	−0.12
(*t*)			(−17.21)	(−17.99)	(−10.23)	(−10.64)	(−11.66)	(−11.01)	(−6.62)	(−8.34)
$log(BA)_{i,t-1}$		−9.32		−8.32		−8.87		−7.15		−9.06
(*t*)		(−22.35)		(−21.91)		(−21.07)		(−36.32)		(−21.29)
$MABA_{i,t-1}$		−1.49		−0.73		−1.75		−0.87		−1.33
(*t*)		(−4.44)		(−2.45)		(−4.70)		(−7.53)		(−3.96)
$Mktlev_{i,t-1}$		48.89		31.46		45.91		53.40		50.87
(*t*)		(23.73)		(16.82)		(22.36)		(47.46)		(24.11)
$log(1 + Delta)_{i,t-1}$		1.77		1.56		1.66		1.61		1.67
(*t*)		(10.15)		(9.59)		(9.71)		(10.62)		(9.82)
$log(1 + Vega)_{i,t-1}$		−0.19		−0.14		−0.13		−0.71		−0.23
(*t*)		(−0.81)		(−0.61)		(−0.56)		(−5.17)		(−0.97)
$1_{MissingExec}$		9.47		8.74		9.07		0.93		8.05
(*t*)		(8.63)		(8.87)		(8.31)		(1.12)		(7.86)
$SUE_{i,t-1}$		0.22		0.21		0.24		0.08		0.20
(*t*)		(2.91)		(3.14)		(3.26)		(1.33)		(2.60)
$Adj.R^2$	0.50	0.55	0.54	0.58	0.51	0.55	0.45	0.50	0.51	0.55
Total number of observations	429,966	411,416	371,056	353,284	418,065	400,101	430,078	411,509	393,650	376,919

Notes. This table reports results from firm-level panel regressions with fixed firm and time effects. We regress quarterly idiosyncratic stock return volatility $v_{i,t}^E$ on a constant, the lagged quarterly RoA, and lagged firm characteristics, as follows:$v_{i,t}^E = a + bRoA_{i,t-1} + cD(.)RoA_{i,t-1} + dD(.) + f\ Control_{i,t-1} + e_{i,t}$,where $D(.)$ is an indicator that identifies a situation in which a firm is more likely to shift risk. The indicator takes a value of one if the $o-score$ of the last quarter is classified into the top tercile ($OS = 3$), if the default probability of Merton is classified into the top tercile ($Def\ Prob$ = 3), if the economy of the previous month is identified in the NBER recession dates, or if the fraction of institutional holdings is classified into the bottom tercile ($Inst = 1$). The past firm characteristics include the natural logarithm of assets $\log(BA)_{i,t-1}$, market-to-book assets $MABA_{i,t-1}$, market leverage $MktLev_{i,t-1}$, and standardized unexpected earnings $SUE_{i,t-1}$ as well as the natural logarithms of the delta and vega of managerial stock options. If the delta and vega are missing from ExecuComp, they are replaced with zero, and the indicator $I_{missingExec}$ is set to one. The standard errors are clustered by firm. Adjusted R^2 is the adjusted R^2s.

the indicator variables. The coefficient on $RoA_{i,t-1}$ is −0.40 (*t*-statistic = −19.11) in Reg I and becomes −0.25 (*t*-statistic = −19.97) in Reg II. This implies that a decline of one standard deviation in $RoA_{i,t-1}$ (0.21) is associated with an increase of 0.05 (0.21 × 0.25) in the idiosyncratic volatility, which is about 11% of its sample median of 0.44.

We next examine whether firms take on more investments with high idiosyncratic risk when they are in distress. When the *o*-score is the proxy for financial distress, the estimated coefficients of $RoA_{i,t-1}$ and $RoA_{i,t-1}D(OS = 3)$ are −0.12 (*t*-statistic = −9.93) and −0.39 (*t*-statistic = −17.99), respectively, in Reg II. That is, among the firms with a high *o*-score, in response to a decrease of one standard deviation in RoA (0.21), $v_{i,t}^E$ increases significantly by 0.11 (i.e., 0.21 × (0.12 + 0.39)), which is about 25% of the sample median of idiosyncratic volatility. Moreover, this increase of 0.11 among the distressed firms doubles the increase of 0.05 among all the firms. When we use an alternative firm-level distress indicator, the probability of default, we obtain similar results. In Reg II, the coefficient on $RoA_{i,t-1}$ is −0.16 (*t*-statistic = −13.38), and the coefficient on $RoA_{i,t-1}D(Def\,Prob{=}3)$ is −0.19 (*t*-statistic = −10.64).

Next, to test the risk-shifting behavior over the business cycle mentioned in prediction 2, we use the NBER recession dates to identify the aggregate distress status. That is, if the economy of the previous month falls within an NBER recession, $D(recess) = 1$. The coefficient on $RoA_{i,t-1}$ is −0.28 (*t*-statistic = −28.77), and the coefficient on $RoA_{i,t-1}I(recess = 1)$ is −0.20 (*t*-statistic = −11.01). That is, in response to a decrease of one standard deviation in RoA (0.21) in the recessions, the idiosyncratic volatility increases by 0.10 (0.21 × (0.28 + 0.20)), which is 67.7% ((0.10 – 0.06) / 0.06) more than the increase of 0.06 in the expansions, confirming that the aggregate distress status induces the asymmetric response as well. This confirms that, similar to the firm-specific distress condition, the bad aggregate states cause the firms to take on more idiosyncratic risk than do the good aggregate states. Moreover, the increase in the idiosyncratic risk, to 0.10 during the recession, in the data are also largely consistent with the optimal increment of 0.1231 in the bad state in the calibrated model as shown in panel A of Table OA2 in the online appendix.

Finally, we examine whether the risk-shifting problem is more severe when the monitoring of management by institutional holders is low. In Reg II, the coefficient on $RoA_{i,t-1}$ is −0.19 (t-statistic = −15.13), and the coefficient on $RoA_{i,t-1}D(Inst=1)$ is −0.12 (t-statistic = −8.34), confirming a stronger negative association between profitability and risk taking in the presence of low monitoring from institutional holders.

In short, we empirically confirm our first two predictions of a negative relation between profitability and future idiosyncratic risk taking, particularly in firms in distress, during economic downturns. We also show that firms subject to less active monitoring have a severer agency conflict problem.

To ensure the robustness of our results, we conduct additional tests with alternative proxies for profitability and idiosyncratic volatility as well as alternative specifications. We report the results in Section B of the online appendix. To summarize, we first use an alternative measure for profitability, RoE_{t_1}, and replace the current independent variable RoA_{t-1} in Equation (10). Then, to mitigate the potential bias from the persistence of the variables, we test the association between the changes in the idiosyncratic return volatility and the changes in RoA. Finally, because the idiosyncratic risk is unobservable, we replace idiosyncratic return volatility with idiosyncratic asset volatility and idiosyncratic cash flow volatility. Overall, we find consistent support for a negative relation between profitability and future idiosyncratic risk taking.

4.3. Empirical Tests of the Conditional CAPM

We now test predictions 3 and 4, which are concerned with the covariance between the equity beta and market return and the stock returns, in the framework of the conditional CAPM. Following Lewellen and Nagel (2006), we use the excess stock market return r_t^m to proxy for the market risk premium λ_t and the monthly CAPM beta to proxy for the time-varying market beta β_t^E. The monthly CAPM beta is obtained by regressing daily returns on daily excess market returns. We also use the procedure of Dimson (1979) to mitigate microstructure noise. Empirically, the unconditional expected stock excess return is

$$\begin{aligned}\mathbf{E}\left[r_t^{ex}\right] &= \mathbf{E}\left[r_t^E\right] - rdt = \mathbf{E}\left[\beta_t^E r_t^m dt\right]\\ &= \mathbf{E}\left[\beta_t^E\right]\mathbf{E}\left[r_t^m\right]dt + \mathbf{cov}\left(\beta_t^E, r_t^m\right)dt, \qquad (11)\end{aligned}$$

and the unconditional CAPM alpha is

$$\alpha^u \approx \mathbf{cov}\left(\beta_t^E, r_t^m\right)dt - \frac{\mathbf{E}\left[r_t^m\right]}{\left(\mathbf{E}\left[\sigma_t^m\right]\right)^2}\mathbf{cov}\left(\beta_t^E, \left(\sigma_t^m\right)^2\right). \qquad (12)$$

4.3.1. Equity Beta and Market Risk Premium.

The mechanism in our model is that the negative covariance, $\mathbf{cov}(\beta_t^E, r_t^m)$, causes the low returns and negative alphas in high-volatility firms. A simple calculation of the covariance of $\mathbf{cov}(\beta_t^E, r_t^m)$ does not allow us to test whether the covariance is potentially driven by the risk-shifting mechanism. To examine the role of the risk shifting, we use panel regressions and introduce into them the interaction term between the market risk premium and the risk-shifting conditioning variables. Additionally, the panel regressions allow us to control for other firm characteristics as well as firm and time fixed effects.

We regress the monthly equity beta, $\beta_{i,t}^E$, on r_t^m as follows:

$$\begin{aligned}\beta_{i,t}^E = a_i + gD(.) + \sum_{j=1}^{J} I_{i,t}(j)\{a_j + b_j r_t^m + c_j r_t^m D(.)\\ + d_j D(.) + f_j Control_{i,t-1}\} + e_{i,t}, \qquad (13)\end{aligned}$$

where $I_{i,t}(j)$ is an indicator function that takes a value of one if firm i is in quintile j and $D(.)$ is an indicator that identifies a high likelihood of financial distress or low institutional holdings by the top five block holders. We classify the firms into quintiles j based on their idiosyncratic return volatility in the last month and into terciles based on their o-score, Merton's default probability and institutional holdings. $D(.) = 1$ if the firm is in the top tercile for the o-score or default probability or in the bottom tercile for institutional holdings. We include control variables, such as marketizatiot(

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idiosyncratic volatility increases, particularly in distressed and less monitored firms. Thus, we are interested in the coefficient $b_j + c_j D(.)$ because it allows us to investigate whether the risk-shifting incentives drive the negative covariance between the market risk premium and levered beta.

[redacted] higher idiosyncratic volatility. For brevity, we report the estimates of b_j and c_j. Panel A shows that the equity beta is negatively correlated with the market returns in all quintiles and becomes increasingly negative as idiosyncratic volatility rises. For the firms in the top quintile, the estimated coefficient is –2.09 (t-statistic = 17.44), which is much greater than the –0.77 (t-statistic = –6.54) for firms in the bottom quintile.

To examine whether the correlation is stronger in firms with a high likelihood of shifting risk, we add the [redacted] increase in absolute terms from –0.55 (t-statistic = –5.26) to –1.28 (t-statistic = –4.06). More importantly, $b_j + c_j D(OS = 3)$ increases *monotonically* in absolute terms from –1.28 to –3.18, confirming that distressed firms

Table 4. Equity Betas and Excess Market Returns

Panel A: Firm-level betas versus market returns					
	L(ow)	2	3	4	H(igh)
$b(j)$	–0.77	–1.09	–1.53	–1.92	

are more negatively correlated with market returns. Similarly, in panel C, where we use the default probability of Merton, all the estimated c_j values decrease from 0.08 to −1.28, and $b_j + c_j D(Def\ Prob = 3)$ increases monotonically in absolute terms from −0.84 to −3.34. Therefore, we confirm consistently that the correlation between the equity beta and excess market returns becomes increasingly negative as the idiosyncratic volatility rises, particularly in the distressed firms.

Finally, we investigate the effect of monitoring on the equity beta. In panel D, where the indicator $D(Inst = 1)$ is for firms with low institutional holdings and monitoring, the estimated c_j increases in absolute terms from −0.59 (t-statistic = −2.47) to −1.50 (t-statistic = −5.38), and $b_j + c_j D(Inst = 1)$ increases in absolute terms from −1.10 to −2.41. This implies that, when the firms are subject to relatively less monitoring from institutional holders, the management is

We conduct extensive tests of the four predictions in the cross-section and in time series. We confirm that, when firms are in distress and when the aggregate economy is in a bad state, equity holders take on more investments with high idiosyncratic risk. We also demonstrate that the increased idiosyncratic risk decreases the equity beta, particularly in the bad states in which the market risk premium is high. More importantly, we find a strong negative covariance between the time-varying equity betas and the market risk premium at the firm level and at the portfolio level among the firms with high idiosyncratic volatility. The negative covariance between the lowered equity beta and the increased market risk premium dominates the leverage effect and generates low excess stock returns and unconditional alpha in the conditional CAPM for the firms with high idiosyncratic volatility. Thus, we deliver a risk-based explanation for the idiosyncratic volatility puzzle in the conditional CAPM instead of the traditional unconditional CAPM.

Although our study assumes the manager is acting on behalf of the equity holders and focuses on the agency conflict between equity and debt holders, it would be fruitful to incorporate managerial incentives in our modeling framework although we do control for managerial compensation in our empirical investigation.

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A.1. Model Setup

The model is partial equilibrium with a pricing kernel, m_t, as follows:[19]

$$\frac{dm_t}{m_t} = -rdt - \theta d\hat{W}_t^m, \qquad \text{(A.1)}$$

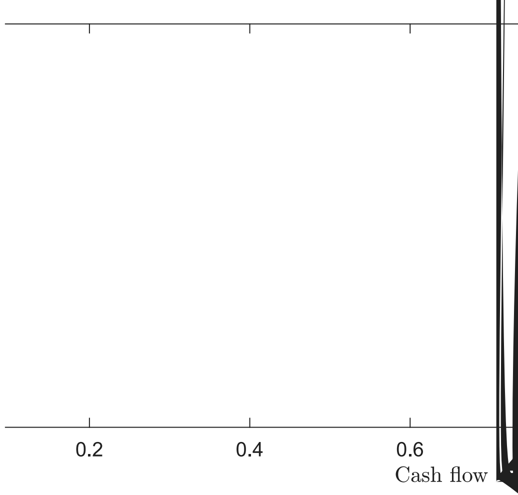
where r is the constant risk-free rate, θ is the price of the risk, and $\hat{W}_t^m$ is a standard Brownian motion.

The economy consists of a large number of firms. Consider a representative firm that operates in two levels of risk, that is, a high and a low risk level. That is, the level, l, can take two values, H (high) or L (low). Before the firm goes

bankrupt, flows X_t stochastic

where $\hat{\mu}_l$ the asset market cash flo motion. is σ_l =

Figure A.1. Optimal Risk Increment and Equity Beta



According to Gordon's growth model under the risk-neutral measure Q, the asset value is as follows:

$$V_{l,t} \equiv V(l, X_t) = \mathbb{E}^Q\left[\int_t^\infty X_\tau e^{-r\tau} d\tau\right] = \frac{X_t}{r - \mu_l}. \tag{A.3}$$

Here, $\mu_l = \hat{\mu}_l - \beta\lambda$ is the risk-neutral counterpart of $\hat{\mu}_l$ and $\lambda = (\theta\sigma^m)$ is the constant market risk premium. Note that this partial equilibrium model is silent on the systematic structure of the risk premium λ.

Because $V_{l,t}$ is linear in X_t in each level, it follows that

$$\frac{dV_{l,t}}{V_{l,t}} = \hat{\mu}_l dt + \beta\sigma^m d\hat{W}_t^m + \nu_l d\hat{W}_{i,t}. \tag{A.4}$$

Ito’s lemma implies that the equity value

The following two boundary conditions determine the threshold X_r:

$$E_{L,r} = E_{H,r} - \eta\epsilon^2 V_{H,r}(1-\tau), \tag{A.25}$$

$$E'_{L,r} = E'_{H,r} - \eta\epsilon^2(1-\tau)/\left(r-\mu_H\right). \tag{A.26}$$

The value-matching condition in Equation (A.25) is the no-arbitrage condition at X_r. Although the asset value decreases from $V_{L,t}$ to $V_{H,t}$ because $\mu_H < \mu_L$, equity holders are able to increase their own wealth to $E_{H,r} \equiv E(l = H, X_t = X_r)$ by increasing the idiosyncratic cash flow growth volatility from ν_L to ν_H at a cost of $\eta\epsilon^2 V_{H,r}(1-\tau)$. Equation (A.26) is the smooth-pasting condition that determines the optimal risk-shifting threshold X_r.

In response to the expected decline from $\hat{\mu}_L$ to $\hat{\mu}_H$, equity holders strategically increase idiosyncratic volatility by ϵ^*. Unlike the exogenous risk increment in Leland (1998), we allow equity holders to choose the optimal increment ϵ^* to maximize the equity value $E_{H,r}$ at X_r after debt is in place:[23]

$$\epsilon^* = \underset{\epsilon}{\operatorname{argmax}}\ E_{H,r} - \eta\epsilon^2 V_{H,r}(1-\tau). \tag{A.27}$$

On the one hand, the excess risk ϵ increases the equity value because of the option-like feature of equity. On the other hand, excess risk taking means greater proportional adjustment costs. Hence, equity holders make a cost–benefit trade-off and determine the optimal excess risk-taking ϵ^* so as to maximize their own wealth at X_r. After obtaining a semiclosed–form solution for X_r as a function of ϵ^*, we solve for ϵ^* and X_r jointly.

The next proposition gives the expected stock return of the preshifting firms, $\mathbf{E}[r^E_{L,t}]$, and the optimal risk-shifting threshold, X_r.

Proposition A.2. *When the firm is in the low risk level, $X_t \geq X_r$, the expected instantaneous stock return $\mathbf{E}[r^E_{L,t}]$ is*

$$\mathbf{E}\left[r^E_{L,t}\right] = rdt + \mathbf{E}$$

In panel (b), we allow the market risk premium θ to change over time. For simplicity, we consider one firm, which is firm 1 in panel (a), that experiences the aggregate good and bad states. We use the constant market risk premium as our benchmark and compare the risk-shifting behavior and the equity beta from the benchmark model with those generated from the case with a time-varying market premium. In the case of state-varying market risk premium, we keep the cash flow growth rate constant, that is, $\hat{\mu}_L = \hat{\mu}_H = 0.04$, between the bad and good states and only allow the market risk premium θ to change. This is to ensure that any difference in risk-shifting behavior generated from this example is entirely because of the increase in the market risk premium. Without losing generality, we assume that the firms increase their idiosyncratic risk taking at the threshold X_r, which is at the same time when the economy enters a bad state and the market risk premium increases from θ_L (0.5) in the good state to θ_H (0.6) in the bad state.

A.5.1. Prediction 1. We list the optimal policies, such as the optimal increment ϵ^*, X_r, and X_d, in the legend of panel (a) of Figure A.1. Although the optimal increment ϵ^* is 0.129 for the firm with a high $\hat{\mu}_H$ of 0.04, it becomes 0.452 for the firm with a low

[6] Recent applications of the option pricing framework include Berk et al. (1999), Carlson et al. (2004), and others.

[7] Additionally, Ferguson and Shockley (2003) show that the financial leverage can help explain the size and value premia. Choi (2013) and Obreja (2013) show that the financial leverage drives the value premium.

[8] We follow Garlappi and Yan (2011) and assume the cash flow beta $\beta = 1$.

[9] Empirically, Davydenko (2008) documents that the majority of firms with negative net worth do not default for at least a year and that the mean (median) of the market value of assets at default is only 66% (61.6%) of the face value of debt. This finding shows the importance of the option to delay bankruptcy.

[10] These two mechanisms have opposite effects on the equity beta. Their relative effects depend not only on their payoffs, but also on the probability that they will be exercised. First, the potential increment in idiosyncratic volatility ϵ has a positive impact on the payoff from the option of increasing volatility. As shown in Equation (4), given the constant cost η, the greater the risk increment ϵ, the greater the payoff $(V_{L,r} - V_{H,r} + \eta\epsilon^2 V_{H,r})$. Second, before the risk is shifted, the likelihood of going bankrupt and the expected value of the option of going bankrupt are small because the firm is still at a low level of risk. Mathematically, the probability of exercising those two options can be approximated by the distance of X_t from their exercising thresholds. When the firm is approaching the high level of risk, $X_t \longrightarrow X_r$, the risk-neutral probability $(X_t/X_r)^{\omega_{L,1}} \longrightarrow 1$ for the option of increasing asset risk, and the risk-neutral probability $(X_r/X_d)^{\omega_{H,1}}$ $(X_t/X_r)^{\omega_{L,1}} \longrightarrow (X_r/X_d)^{\omega_{H,1}} \leq 1$ for the option of delaying bankruptcy.

[11] Consider the firm in panel (b) of Figure A.1. Its equity betas (dotted line) decrease after the firm increases its idiosyncratic risk at $X_r = 0.446$, where the market risk premium increases. Hence, the betas negatively covary with the market risk premium.

[12] They demonstrate that the third item $\frac{\mathbf{E}[r_t^m]}{(\mathbf{E}[\sigma_t^m]^2 \mathbf{cov}(\beta_t^E,(r_t^m - \mathbf{E}[r_t^m])^2)}$ is trivial.

[13] Consider the numerical example in the appendix. In panel (b) of Figure A.1, the equity betas (shown by the dotted line) in the distressed area where $X_t < X_r = 0.446$ are greater than those in the healthy area where $X_t > 0.8$.

[14] The changes in asset values, V_t, are not a result of the investments, but entirely driven by the cash flow shock, X_t. As shown in Equations (A.2) and (A.4), the asset growth dV_t/V_t is exactly the same as the growth of cash flow dX_t/X_t, that is, $dV_t/V_t = dX_t/X_t$. We assume that the change $dV_t = X_t$, and therefore, $dV_t/V_t = X_t/V_t$, which is profitability.

[15]

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