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Empirical Evidence of Risk Shifting in Financially Distressed Firms

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ABSTRACT

This paper provides evidence of risk-shifting behavior in the investment decisions of financially distressed firms. Using a real options framework, I show that shareholders' risk-shifting incentives can reverse the expected negative relation between volatility and investment. I test two hypotheses that are consistent with risk-shifting behavior: (i) volatility has a positive effect on distressed firms' investment; (ii) investments of distressed firms generate less value during times of high uncertainty. Empirical evidence using 40 years of data supports both hypotheses. I further evaluate the effect of various firm characteristics on risk shifting, and estimate the costs of the investment distortion.

SHAREHOLDERS OF FINANCIALLY distressed firms may have incentives to invest in risk-increasing negative-NPV projects, as they reap the benefits if things go well, whereas the bondholders bear the costs if things go poorly. Since Galai and Masulis (1976) and Jensen and Meckling (1976) introduced this risk-shifting (asset substitution) problem, many theoretical papers have sought to identify factors that can mitigate the problem (e.g., debt structure, compensation, and regulation) and to assess its extent. There is very little empirical evidence, however, of whether the problem actually exists.

In this paper I empirically examine risk-shifting behavior in distressed firms by studying the relation between investment and volatility. This relation is analyzed in the literature mainly using a real options approach. Under the real options logic, a firm's investment decision involves a tradeoff between realizing early cash flows by immediately investing in a project, and gaining more information about the value of the project by delaying investment. Since the value of delaying investment increases with the degree of uncertainty about the project's cash flows, current investment is expected to decline with a rise in volatility (see McDonald and Siegel (1986), Pindyck (1988), Dixit and Pindyck (1994), and Trigeorgis (1996)). The empirical evidence generally supports the negative relation between investment and volatility (see Pindyck and Solimano (1993), Episcopos (1995), Caballero and Pindyck (1996), Ghosal and Loungani (1996), Leahy and Whited (1996), and Bulan (2003)).

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When a firm is in financial distress, in addition to real options considerations, risk-shifting incentives also play a role in the investment-volatility relation. As high risk benefits the shareholders of distressed firms, an increase in the volatility of a project may provide an opportunity for shareholders to increase value by investing in a risky project. In this case, volatility has two opposing effects on current investment—a negative effect of the option to delay investment and a positive effect of risk shifting.

I construct a three-date model that captures both the incentive to delay investment when available projects become riskier and the incentive to increase investment in risky projects, and show that the latter effect can dominate the former. This implies that the negative relation between investment and volatility derived from the real options framework can be reversed when there is high risk of default.

Based on the model's implications, I examine the existence of the risk-shifting problem by testing two hypotheses. The first hypothesis posits that there is a weaker negative relation, or even a positive relation, between investment and volatility in distressed firms. The second hypothesis, which follows from the risk-shifting considerations embedded in the investment decision, conjectures that during periods of high volatility, investments of distressed firms are expected to generate less value. I find empirical support for both hypotheses, indicating substantial risk-shifting behavior in financially distressed firms.

In addition, I examine a variety of factors that are expected to affect the incentive and ability of shareholders to increase firm risk. Consistent with the theoretical literature, secured debt is found to play a significant role in mitigating risk shifting, and assumption of short-term and convertible debt also reduces the extent of the problem. The results further show that risk-shifting behavior is more likely to occur in firms with more growth opportunities, in unregulated firms, and in firms where managers' and shareholders' interests are aligned.

Finally, I construct a measure to evaluate the costs imposed on bondholders due to risk shifting, and find that the value of debt is reduced by approximately 6.4% as a result of overinvestment in high-volatility periods.

The paper proceeds as follows. The next section reviews the literature on the risk-shifting problem. Section II models the effect of risk-shifting incentives on the relation between investment and volatility. Section III empirically tests the hypotheses associated with risk-shifting behavior, examines how various factors help mitigate the problem, and estimates the costs of the investment distortion. Section IV provides robustness tests, and Section V concludes.

I. Related Literature

Since Galai and Masulis (1976) and Jensen and Meckling (1976) introduced the risk-shifting problem as one of the conflicts of interest between shareholders and bondholders, many studies have analyzed the relation between the potential costs of risk shifting and a firm's characteristics.

Smith and Warner (1979) analyze how various types of bond covenants help reduce agency costs, and argue that restrictions on investments, restrictions on disposition of assets, and secured debt help mitigate the risk-shifting problem. The relation between secured debt and potential agency costs has been investigated empirically in several studies, with mixed results (see Titman and Wessels (1988), Friend and Lang (1988), and Barclay and Smith (1995b)).

Convertible debt has also been analyzed with respect to risk shifting. Green (1984) shows in a single-period framework that since convertible debt reverses the convex shape of levered equity over the upper range of a firm's value, it reduces shareholders' incentives to take risk. Other studies, extending Green's work, show that the ability of convertible debt to reduce risk-shifting incentives may vary under different frameworks (see Barnea, Haugen, and Senbet (1985), Frierman and Viswanath (1993), Chesney and Gibson-Asner (2001), Ozerturk (2002), and Hennessy and Tserlukevich (2004)).

Barnea, Haugen, and Senbet (1980) link risk-shifting to debt maturity. They argue that since the value of short-term debt is less sensitive than the value of long-term debt to changes in asset volatility, issuing short-term debt can reduce risk-shifting incentives. They predict that debt with shorter maturity will be used when the potential costs of risk shifting are high. Barclay and Smith (1995a) and Guedes and Opler (1996) provide evidence consistent with this hypothesis; firms with more growth options (and therefore higher potential agency costs) have more short-term debt in their capital structure.

Brander and Poitevin (1992), John and John (1993), and Subramanian (2003) model the effect of managerial compensation contracts on the risk-shifting problem, and show that there is an optimal compensation structure that mitigates the problem. Eckbo and Thorburn (2003) argue that control benefits of managers mitigate costly shareholder risk-shifting incentives during severe financial distress. Diamond (1989, 1991) shows that an interest in reputation building can motivate firms, especially young firms and firms in distress, to borrow from banks for the purpose of certification and monitoring, reducing incentives to increase the firm's risk.

In addition to identifying factors that can mitigate the risk-shifting problem, the literature has tried to assess the significance of the costs associated with risk-shifting incentives, and their ability to explain the firm's capital structure.

Using a dynamic model, Leland (1998) shows that the costs of the risk-shifting problem are low compared to the tax-based benefits of issuing debt, and are not expected to affect leverage significantly. Ericsson (2000), who also uses a dynamic framework, draws a different conclusion, showing that the costs of risk-shifting incentives are very significant and can reduce the firm's optimal leverage by up to 20%.

Parrino and Weisbach (1999) use a Monte Carlo simulation to assess the significance of several conflicts between bondholders and shareholders. Finding that costs of debt due to risk shifting are negligible for most firms (although levered firms have incentives to engage in risky negative-NPV projects), they conclude that the potential for risk shifting is not a significant factor in determining optimal capital structure.

Although a large number of studies theoretically analyze the implications of the risk-shifting problem, no study has directly assessed the actual existence of the problem using a uniform measure across a large sample of firms. Andrade and Kaplan (1998) examine cases of large investments in unusually risky projects within 31 financially distressed firms and find no evidence of risk-shifting behavior. De Jong and Van Dijk (2001) examine the extent of the problem using questionnaires sent to CFOs of 102 firms listed on the Amsterdam Stock Exchange and find no evidence of risk shifting. Graham and Harvey (2001) survey CFOs of 302 U.S. and Canadian firms and find little evidence that executives are concerned about risk shifting.

II. The Effect of Risk-Shifting Incentives on the Relation between Investment and Volatility

A real options approach suggests that when a firm has an option to delay an irreversible investment, it will prefer to do so if the value of waiting exceeds the NPV from immediate investment (see, for example, McDonald and Siegel (1986)). Since the value of delaying an investment increases with the degree of uncertainty about its payoff, investment is expected to decrease in volatility. Static setups, however, suggest that in financially distressed firms, equityholders have an incentive to invest more when projects are risky. I construct a three-date model that captures both of the aforementioned effects of volatility on investment, and show that the risk-shifting effect can reverse the negative relation between volatility and investment when there is considerable risk of default.

A. Framework

Consider three dates, separated by an equal time interval, t. At date 0, the firm's only asset is cash in the amount of C_0. The firm's claimants include equityholders and debtholders, and the former control the firm's investment policy. The firm's debt has a face value of D, pays no coupon at date 1, and matures at date 2.[1] The firm has an option to invest in a risky asset, which can be exercised either at date 0 or 1. The asset requires a fixed investment of C_0, which means that the firm can invest in the asset without any external financing. This assumption ensures that the firm's investment policy is not affected by considerations associated with debt or equity issues. In other words, the firm has the ability to substitute assets with no further costs.

[1] Prior studies assume that the choice of the firm's leverage is endogenous in order to assess how the firm's optimal leverage is affected by expected costs of risk shifting (see, for example, Leland (1998) and Ericsson (2000)). Others assume that the choice of leverage is taken as given when assessing the effect of debt on risk-based decisions (see, for example, Subramanian (2003)). I adopt the latter assumption, as the objective of this study is to address the existence of the risk-shifting problem. That is, I model risk-shifting behavior of managers who face risky investment opportunities when debt is already in place.

The value of the risky asset consists of a random factor, x, which is determined exogenously, and coupons generated by the asset in each period at a constant rate $\delta > 0$ (i.e., δ represents the profit margin of the asset). Assume that x follows a geometric Brownian motion of the form

$$dx = \mu x dt + \sigma x dW, \tag{1}$$

where μ and σ are the asset's drift and volatility, and W is a standard Wiener process.

At any time prior to the investment in the risky asset, the return on the firm's cash is also uncertain, which represents alternative, less risky, investment opportunities. Specifically, assume that the amount of cash follows a geometric Brownian motion with drift r and volatility $\sigma_c < \sigma$, and that the correlation between the returns on the cash and the risky asset is ρ. Assume also that profits generated by the asset before date 2 earn a risk-free rate, r, in each period, and that the asset is liquidated at date 2.

The value of the firm at date 2 depends on the firm's investment policy as follows. If the firm invests at date 0, it receives the coupons generated by the asset at dates 1 and 2, as well as the final value of the asset. Hence, in this case the value of the firm at date 2 is $\delta x_1 e^{rt} + (1+\delta)x_2$. If the firm invests at date 1, its value at date 2 comprises the change in the amount of cash between dates 0 and 1, the coupon of the asset at date 2, and the final value of the asset, that is, $(C_1 - C_0)e^{rt} + (1+\delta)x_2$ (x_i and C_i are the values of the risky asset and the cash holdings, respectively, at date i). If the firm does not invest at all, its value at date 2 is simply the future value of the cash holdings, C_2. Thus, delaying the investment decision involves a tradeoff between giving up the first coupon of the asset and gaining more information about the value of the asset.

Assume further that all proceeds are distributed to the firm's claimants only at date 2. This assumption ensures that any incentive the equityholders have to invest early is driven only by changes in asset volatility and not by the benefits of early payments before the debt matures. This assumption is essential to isolate the effect of the risk-shifting problem on investment policy from the influence of other shareholder-bondholder conflicts, such as the dividend payout.

Hence, in each case the value of the firm's equity at date 2 is the cash flow minus the debt payment (bounded by zero) as specified below:

$$\begin{array}{ll} \max[(1+\delta)x_2 - (D - \delta x_1 e^{rt}), 0] & \text{if investing at date 0} \\ \max[(1+\delta)x_2 - (D - (C_1 - C_0)e^{rt}), 0] & \text{if investing at date 1} \\ \max[C_2 - D, 0] & \text{if not investing at all.} \end{array} \tag{2}$$

The objective of the model is to examine the overall effect of the asset volatility (σ) on the investment policy at date 0 when risk-shifting incentives are taken into account.

The model is solved by backward induction. At date 1, given the value of x_1, the firm will invest in the asset if the expected payoff to the equityholders increases with the investment, as represented by the following inequality:

$$\int_{\frac{\max[D-(C_1-C_0)e^{rt},0]}{1+\delta}}^{\infty} [(1+\delta)x_2 - \max[D-(C_1-C_0)e^{rt},0]] f(x_2)\,dx_2 + \max[(C_1-C_0)e^{rt}-D,0] > \int_D^{\infty} (C_2-D) f(C_2)\,dC_2, \tag{3}$$

where $f(x_2)$ is the density function of a lognormal distribution with parameters $x_1 e^{\mu t}$ and $x_1^2 e^{2\mu t}(e^{\sigma^2 t}-1)$, and $f(C_2)$ is the equivalent function with parameters $C_1 e^{rt}$ and $C_1^2 e^{2rt}(e^{\sigma_c^2 t}-1)$.[2] The first max term on the left-hand side represents the effective change in the firm's liabilities according to the change in the cash holdings between dates 0 and 1; when the change in cash exceeds the face value of debt, the debt is fully paid and the equityholders earn the difference (represented in the second max term).

Condition (3) implies that the firm will invest in the asset if its value at date 1 is higher than a threshold. Equivalently, the firm will invest if

$$x_1 > TR_1. \tag{4}$$

At date 0, given the initial value of the asset and the investment threshold at date 1, TR_1, the firm will invest in the asset only if the expected value of the equity when investing exceeds the value when delaying the investment decision. Hence, the investment threshold at date 0 is equal to the initial value of the asset, x_0^*, that satisfies the following equation:

$$\int_0^{\infty}\left[\int_{\frac{\max[D-\delta x_1 e^{rt},0]}{1+\delta}}^{\infty} [(1+\delta)x_2 - \max[D-\delta x_1 e^{rt},0]] f(x_2)\,dx_2 + \max[\delta x_1 e^{rt}-D,0]\right] \times f(x_1)\,dx_1 = \int_0^{\infty}\int_0^{TR_1}\left[\int_D^{\infty}(C_2-D)f(C_2)dC_2\right] f(x_1,C_1)\,dx_1 dC_1 + \int_0^{\infty}\int_{TR_1}^{\infty}\left[\int_{\frac{\max[D-(C_1-C_0)e^{rt},0]}{1+\delta}}^{\infty}[(1+\delta)x_2-\max[D-(C_1-C_0)e^{rt},0]] f(x_2)\,dx_2 + \max[(C_1-C_0)e^{rt}-D,0]\right] f(x_1,C_1)\,dx_1 dC_1, \tag{5}$$

where the left-hand side and the right-hand side represent the equity value conditional on an immediate investment and conditional on delaying the investment decision, respectively; $f(x_1)$ and $f(x_1, C_1)$ are the marginal and joint density functions of the lognormal distributions with parameters equivalent to the ones in equation (3)[3]; and, similarly to equation (3), the max terms on the left-hand side represent the adjustments to the firm's debt according to the proceeds at date 1.

As there is no closed-form solution to the investment threshold, I use a numerical solution to evaluate the effect of volatility on investment under different levels of default risk.

[2] The lognormal distribution is implied by the geometric Brownian motion.

[3] The parameters of these distributions are functions of x_0^*.

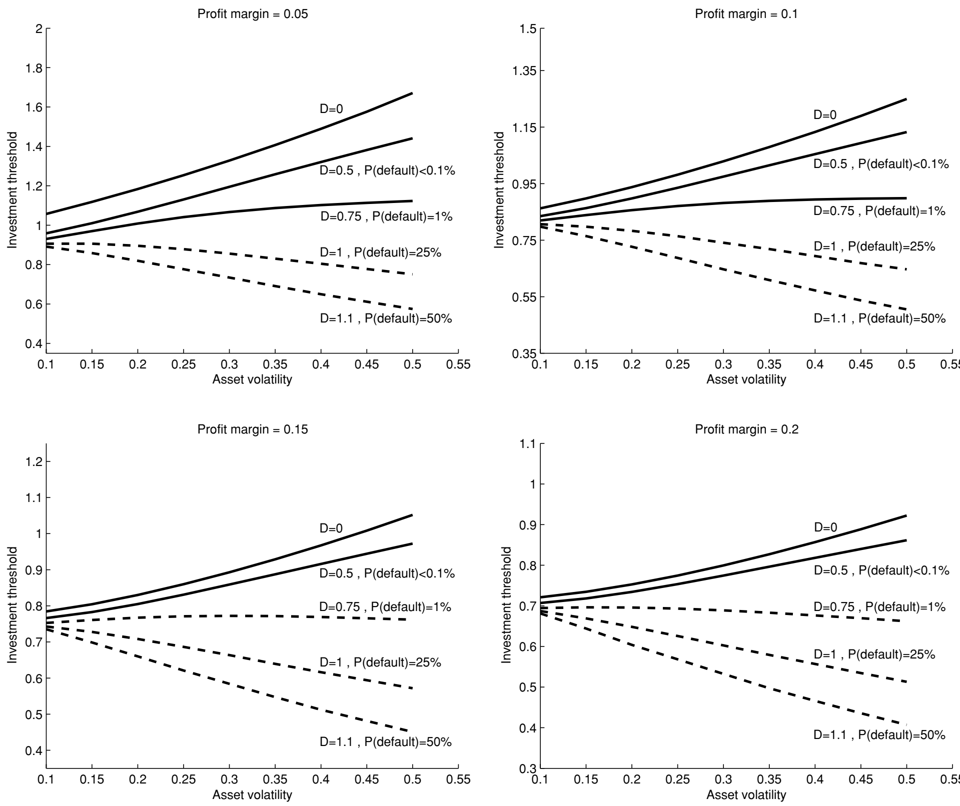

Figure 1. The effect of risk-shifting incentives on the relation between investment and volatility. The figure shows the investment threshold at date 0 as a function of the asset volatility, σ. The four graphs represent different values of the profit margin, δ, and each graph represents five levels of default risk, given by the probability that the face value of debt, D, will exceed the cash holdings at date 2, C_2. The investment threshold is derived numerically from equation (5) using the following values: $C_0 = 1, r = 0.05, \sigma_c = 0.1, \mu = 0.05, \rho = 0$, and $t = 1$.

B. Numerical Solution

Figure 1 shows the value of the investment threshold at date 0 as a function of the asset volatility for different profit margins and for different levels of default risk. The profit margin, δ, ranges between 0.05 and 0.2. A positive δ is required to ensure a tradeoff between the benefits of early investment and the benefits of delaying the investment decision, where a higher δ implies a stronger incentive to invest at date 0. The level of default risk is represented by different values of D, and is given by the probability that D will exceed C_2 at date 2. The remaining parameters are set as follows: $C_0 = 1, r = 0.05, \sigma_c = 0.1, \mu = 0.05, \rho = 0$, and $t = 1$.[4] As expected, when there is no default risk, the investment threshold increases with the asset volatility, which implies a negative relation between

[4] The implications of the model are robust to the values of these parameters.

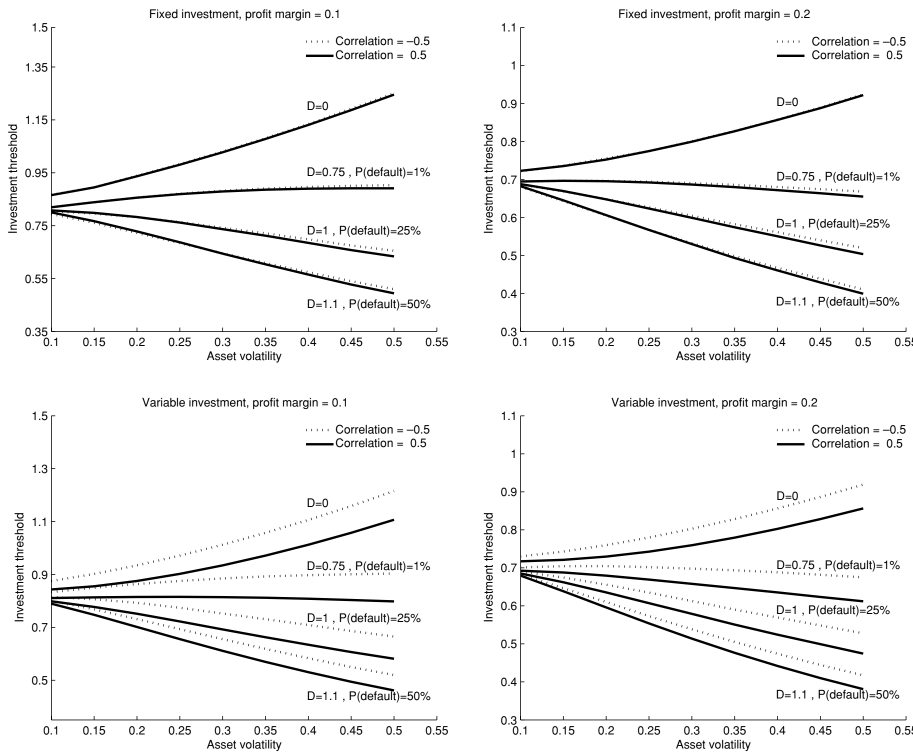

Figure 2. The effect of risk-shifting incentives on the relation between investment and volatility. (continued.) The figure shows the investment threshold at date 0 as a function of the asset volatility, σ, while incorporating the correlation between the risky asset and the cash holdings. Results are presented for the cases of fixed investment and variable investment, as described in Section II. The graphs represent different values of the profit margin, δ, and different levels of default risk, given by the probability that the face value of debt, D, will exceed the cash holdings at date 2, C_2. The investment threshold is numerically derived from equation (5) using the following values: $C_0 = 1, r = 0.05, \sigma_c = 0.1, \mu = 0.05$, and $t = 1$.

investment and volatility. In addition, the results show that at any level of δ, this negative relation is weakened with the level of default risk,[5] and even becomes positive when default risk is high.

Figure 2 addresses the effect of the correlation between the risky asset and the cash holdings (i.e., the alternative investments). Since the risky asset requires a fixed investment at any period, the NPV of the investment in the asset at date 1 is independent of the cash holdings at this date. Hence, the correlation between the risky asset and the cash holdings has no significant effect on the firm's investment policy, as reflected in the upper two graphs in Figure 2.[6]

[5] This result is consistent with Mauer and Sarkar (2004), who show that risk-based considerations may lead shareholders to exercise investment options too early.

[6] There are still some differences between the thresholds since the leverage ratio, which is relevant for the investment decision, changes with the cash holdings.

The correlation has a noticeable effect on the investment decision when the fixed-investment assumption is relaxed, particularly when the investment required for the risky asset depends on the firm's cash. Assume, therefore, that the required investment at date 1 is proportional to the cash holdings available at this date. This assumption can be incorporated by replacing C_0 with KC_1 in equations (2) to (5), where K is a positive constant. The lower two graphs in Figure 2 depict the results under the variable-investment assumption, with $K = 1$. A negative correlation is now associated with a lower investment threshold. The intuition behind this result is that a negative correlation is more likely to differentiate between the values of the alternative investments at date 1, which makes the option to delay the investment decision more valuable. However, while the correlation between the risky asset and the cash holdings can affect the level of investment, it does not change the effect of risk-shifting incentives on the investment policy, as under both values of the correlation, high-default risk implies that volatility has a positive effect on current investment.

The results in Figures 1 and 2 suggest that for firms in significant financial distress, the positive effect of risk shifting on the volatility-investment relation can dominate the negative effect of the delaying value on this relation. It is also important to observe that the difference between the investment thresholds of healthy and distressed firms, which represents the investment distortion as a result of risk-shifting incentives, increases with the asset volatility. Thus, in high-volatility periods, investments of distressed firms are expected to be less valuable.

III. Empirical Tests

A. Hypotheses

Based on the model's implications, risk-shifting behavior is consistent with the following two hypotheses:

- H1: The level of uncertainty has a weaker negative effect, or even a positive effect, on the investment of financially distressed firms.
- H2: The effect of investment on asset value in financially distressed firms diminishes as the level of uncertainty increases.

Testing the hypotheses requires estimation of expected volatility (at both the market and industry levels, as a measure of uncertainty), and firm-level investment intensity, asset value, and the extent of financial distress.

B. Estimation

Expected volatility. To measure conditional expected market volatility, I use generalized autoregressive conditional heteroskedasticity (GARCH) models, introduced by Engle (1982) and developed by Bollerslev (1986). GARCH models require high-frequency data and long time-series observations, while my tests are performed using annual data. I therefore estimate annual expected market volatility as follows.

First, I apply a GARCH (1,1) model to monthly returns of the NYSE market index from 1927 to 2002.[7] This yields time-series observations of k-step-ahead expected volatility for each month during that period. Then, for each calendar year, the expected volatility is measured by the 12-month-ahead forecasted volatility conditional on information available in the last month of the year before.[8] As market volatility does not coincide perfectly with the volatility of the different industries, I also examine the results using expected industry volatility, which is estimated by applying a GARCH (1,1) model to the value-weighted average monthly return of each industry (based on two-digit SIC codes).[9]

Figure 3 shows the monthly expected market volatility and the average of the monthly expected industry volatilities over 1963 to 2002 (the test period). The pattern of expected volatility is consistent with previous studies (e.g., Schwert (2002)).

Investment intensity. Most studies measure firm-specific investment intensity by capital expenditures scaled by either total assets (see Kaplan and Zingales (1997), Mayers (1998), and Korkeamaki and Moore (2004)), or property, plant, and equipment (PP&E) (see Fazzari, Hubbard, and Petersen (1988) and Hoshi, Kashyap, and Scharfstein (1991)). I focus on gross capital expenditures divided by PP&E at the beginning of the year.[10]

Asset value. Similar to the approach described in Crosbie and Bohn (2002) for measuring default risk, I estimate the market value of the firm's total assets

[7] This is a common model of monthly stock returns. Bollerslev, Chou, and Kroner (1992) argue that most financial series can be modeled by GARCH (1,1). See also Akgiray (1989), Pagan and Schwert (1990), West and Cho (1995), Andersen and Bollerslev (1998), and Hansen and Lunde (2005). My results are robust to other common GARCH models.

[8] As implied by the GARCH (1,1) model, the forecasted variance for the period $t+k$, conditional on the information available in period t, is given by the equation $E_t[\sigma^2_{t+k}] = (\alpha_1+\beta_1)^{k-1}[\sigma^2_{t+1} - \alpha_0/(1-\alpha_1-\beta_1)] + \alpha_0/(1-\alpha_1-\beta_1)$, where the mean and the conditional variance equations are $R_t = \gamma + \varepsilon_t$ (R_t is the market return in month t, and $\varepsilon_t \sim N(0,\sigma^2_t)$) and $\sigma^2_t = \alpha_0 + \alpha_1\varepsilon^2_{t-1} + \beta_1\sigma^2_{t-1}$, respectively. Since the residuals of the mean equation, and thus monthly returns, are assumed to be serially independent, the expected variance in period t for the following year is given by adding the 12-step-ahead variance forecasts, that is,

$$E_t\left[\sigma^2_{t,k}\right] = \sum_{k=1}^{12} E_t\left[\sigma^2_{t+k}\right] = \sum_{k=1}^{12} (\alpha_1+\beta_1)^{k-1}\left[\sigma^2_{t+1} - \alpha_0/(1-\alpha_1-\beta_1)\right] + \alpha_0/(1-\alpha_1-\beta_1).$$

This equation suggests that the expected annual variance is a linear function of the expected variance for the next month, σ^2_{t+1}, and thus of the expected variance for any month during the year. Hence, to examine the effect of expected annual volatility on the firm's investment intensity in a given year, conditional on the information available at the beginning of the year, it is sufficient to regress annual investment on expected volatility for the first month of the year.

[9] The sample period used to generate the industry-specific GARCH parameters depends on the availability of firm-specific returns within an industry; for almost all industries, returns in CRSP start between 1950 and 1962, where industry-years with less than five observations are not used in the estimation.

[10] The results are robust to alternative measures of investment intensity.

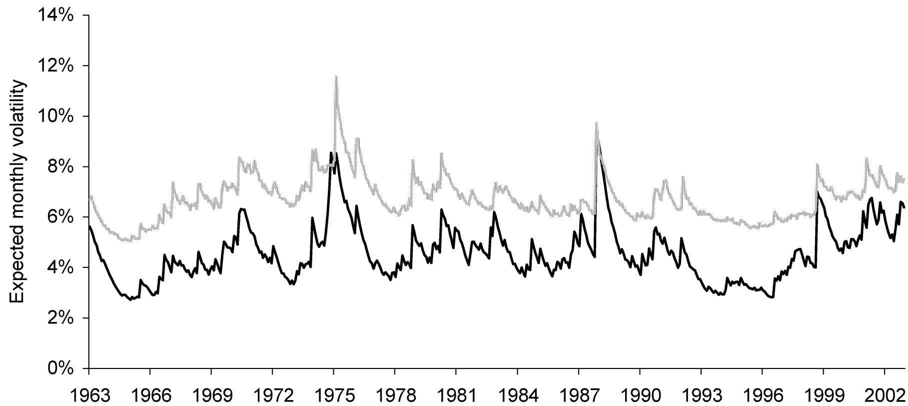

Figure 3. Estimation of expected volatility using GARCH models. At the market level, expected volatilities are estimated by applying a GARCH (1,1) model to monthly returns of the NYSE market index from 1927 to 2002. At the industry level, expected volatilities are estimated by applying the same model separately to the average monthly return of each industry (based on two-digit SIC codes). The sample period used to generate the industry-specific GARCH parameters is based on the availability of firm-specific returns within an industry, where for almost all industries, returns start between 1950 and 1962. The solid (lower) and the dashed (upper) lines represent the monthly expected market volatility and the average of the monthly expected industry volatilities, respectively, over the period 1963 to 2002.

using a two-equation system.[11] The first equation, based on Merton (1974), expresses the value of the firm's equity as the value of a call option on the firm's total asset using the Black and Scholes (1973) formula

$$V_E = V_A N(d_1) - FVe^{-rT} N(d_2), \tag{6}$$

where V_E is the market value of the firm's equity, V_A is the market value of the firm's total assets, $N(\cdot)$ is the cumulative function of a standard normal distribution, $d_1 = [\ln(V_A/FV) + (r + \sigma_A^2/2)T]/[\sigma_A\sqrt{T}]$, $d_2 = d_1 - \sigma_A\sqrt{T}$, σ_A is the asset volatility, *FV* is the face value of debt, *r* is the risk-free rate, and *T* is the time to maturity of debt.

The second equation, a straightforward derivation of Ito's lemma, represents the relation between equity volatility (σ_E) and asset volatility:

$$\sigma_E = \frac{V_A N(d_1)\sigma_A}{V_E}. \tag{7}$$

I use estimates of V_E, σ_E, FV, T, and r to calculate the unobservable V_A and σ_A. Solving simultaneously equations (6) and (7) for each firm in each

[11] The common measure in the literature of the market value of total assets is the sum of the market value of equity and the book value of debt, primarily because the market value of debt is not observable. Since risk-shifting behavior implies a reduction in the market value of debt, using this measure may not capture the reduction in debt value. Hence, I use the two-equation system to generate a measure of the value of total assets that captures both the market value of equity and the market value of debt.

year generates firm-level time-series estimates of asset value and asset volatility.[12]

The inputs for the two-equation system are estimated as follows. The market value of equity, V_E, is measured by the stock price multiplied by the number of shares outstanding. The face value of debt, FV, is measured by the total liabilities of the firm. The risk-free rate, r, is measured by the 1-year Treasury bill yield. The debt maturity, T, is measured as follows. While the model assumes a single class of debt, in practice a firm usually has several types of debt with different maturity horizons. Hence, a single-debt-equivalent estimator for debt maturity should be based on a weighted average of the maturities of all the firm's bonds.[13] For the purposes of this study, I measure debt maturity by the book value-weighted average of the maturities of short- and long-term debt.[14] Short-term debt is defined as debt that matures within 1 year, and long-term debt as debt with a maturity of over 1 year. Following Barclay and Smith (1995a), who find the median maturity of long-term debt to be approximately 5 years, and assuming a uniform distribution of short-term debt (i.e., median maturity of 6 months), the firm's average debt maturity is estimated by

$$\hat{T} = \frac{1}{TD}(0.5\,STD + 5\,LTD), \tag{8}$$

where TD, STD, and LTD are the book values of total, short-term, and long-term debt. Finally, the equity volatility, σ_E, is measured by the realized monthly stock return volatility in the subsequent year.

Extent of financial distress. There are several models for measuring a firm's level of financial distress and its probability of going bankrupt in the short run. The different models are based on accounting data, stock market data, and bond ratings, and are mainly constructed using multiple discriminant analysis (e.g., Altman (1968)) or multiple choice analyses, such as logit (e.g., Ohlson (1980)) and probit (e.g., Zmijewski (1984)). I use Altman's Z-score, a widely used model of bankruptcy prediction.[15] For robustness, I examine the results using two additional measures (see Section IV).

C. Data

The data are obtained from CRSP and COMPUSTAT, where for a firm to be included in the sample, it must have the variables required for computing asset value, investment intensity, and Z-score. After including all firms traded on the

[12] The two-equation system is solved for V_A and σ_A using initial values of $V_E + FV$ and σ_E, respectively.

[13] Crosbie and Bohn (2002) and Hillegeist, Keating, Cram, and Lundstedt (2004) use debt maturity of 1 year for all firms in similar equations for modeling default risk.

[14] I do not use the year-specific maturity data provided in COMPUSTAT because they have many missing and unreliable values (for more details on these data, see Barclay and Smith (1995a)).

[15] Altman's Z-score model for predicting bankruptcies is: Z-score = 1.2(Working capital/Total assets) + 1.4(Retained earnings/Total assets) + 3.3(Earnings before interest and taxes/Total assets) + 0.6(Market value of equity/Book value of total liabilities) + 0.999(Sales/Total assets).

Table I
Descriptive Statistics

This table presents descriptive statistics on the sample firms, where for all variables, observations outside the top and the bottom percentiles are excluded. P25, P50, and P75 indicate the 25^{th}, 50^{th}, and 75^{th} percentiles, respectively, of each variable. Asset value (in millions of dollars) and asset volatility are calculated by solving equations (6) and (7). Investment intensity is estimated by the ratio of capital expenditures to PP&E at the beginning of the year. Z-score is based on Altman's (1968) model for predicting bankruptcy. The market-to-book ratio is equity market value divided by equity book value. Leverage is the book value of total liabilities as a fraction of the book value of total assets. Debt maturity is estimated by a weighted average of the short- and long-term debt of the firm, as defined in equation (8). Cash flow is the firm's operating cash flow divided by PP&E at the beginning of the year. The results are based on 52,112 firm-years over the period 1963 to 2002.

	Mean	StdD	P25	P50	P75
Asset value	820.39	2033.95	30.02	106.74	525.41
Asset volatility	0.25	0.16	0.14	0.21	0.32
Investment intensity	0.17	0.16	0.07	0.12	0.20
Z-score	3.49	2.02	2.20	3.20	4.33
Market-to-book	1.65	1.44	0.78	1.25	1.98
Leverage	0.27	0.15	0.15	0.26	0.37
Debt maturity	3.91	1.11	3.47	4.32	4.71
Cash flow	0.19	0.22	0.09	0.16	0.26

NYSE, AMEX, and Nasdaq that satisfy these conditions, the final sample contains 52,112 firm-year observations over the period 1963 to 2002, representing 7,114 different firms.

Table I presents descriptive statistics on asset value, asset volatility, investment intensity, Z-score, market-to-book ratio, leverage, debt maturity, and cash flow.[16] The estimates are comparable with values reported in other studies. Mean asset volatility of 0.25 in my sample is similar to the values reported in Cooper and Davydenko (2003), Schaefer and Strebulaev (2004), and Eom, Helwege, and Huang (2004), who estimate asset volatility using several techniques, including the one used in this study. Mean investment intensity of 0.17 is comparable with the values in Whited (1992) and Gilchrist and Himmelberg (1995) (0.18 and 0.15, respectively). Mean Z-score of 3.49 is consistent with Altman's (2000) analysis of Z-score means over time. Means of market-to-book and leverage of 1.65 and 0.27, respectively, are very close to those reported in Barclay, Morellec, and Smith (2006). Mean debt maturity of 3.91 is somewhat higher than the values in Stohs and Mauer (1996) and Jun and Jen (2003) (3.38 and 3.08, respectively).

[16] The market-to-book ratio is measured by the market value of equity divided by the book value of equity; leverage is calculated by the book value of total liabilities as a fraction of the book value of total assets; and cash flow is the firm's operating cash flow divided by PP&E at the beginning of the year.

D. Primary Results

D.1. Hypothesis 1

Table II examines the effect of expected volatility on investment separately for financially healthy and distressed firms. Following Altman (1968), firms with Z-scores below 1.81 at the beginning of the year are classified as financially distressed. Panel A shows the results of a linear regression of firm-specific actual investment in a given year on expected market volatility at the beginning of the year; Panel B shows similar results for industry-adjusted investment and expected industry volatility.[17] Firm size, market-to-book, leverage (all as of the beginning of the year), and lagged operating cash flow are included as control variables as they may affect the firm's investment policy. In addition, to eliminate possible marketwide effects on investment, I include three variables that represent the state of the economy, namely, the NBER recession indicator, the default risk spread, which is the yield spread between long-term Baa- and Aaa-rated securities (taken from the Federal Reserve Bank of St. Louis's website), and the interest rate, as measured by the nominal return on 1-month Treasury bills. Since the tests in this study rely on long time-series firm-level data, the Newey and West (1987) procedure, modified for panel data, is used to correct for heteroskedasticity and serial correlation.[18]

For healthy firms, the results show a significant negative relation between expected volatility and investment (t-statistics of −3.10 and −2.56). This result is consistent with prior research (see, for example, Pindyck and Solimano (1993) and Episcopos (1995)). For distressed firms, however, expected volatility has a positive effect on current investment (t-statistics of 1.72 and 2.58). This finding supports Hypothesis 1, consistent with risk-shifting behavior in distressed firms.

The results in Table II are informative because they show that expected volatility generally has opposite effects on investment within financially healthy and distressed firms. Yet, since the Z-score is a continuous measure, I test the relation between volatility and investment when taking into account the level of financial distress.

Table III shows the results of a linear regression of investment on an interaction variable between expected volatility and the firm's level of financial distress (the Z-score). As a lower Z-score implies a higher probability of default, a negative coefficient on the interactive variable is consistent with Hypothesis 1; that is, for low Z-score firms (distressed firms), volatility is expected to have a stronger positive effect on investment. The results support the hypothesis, as the coefficient on the interactive variable is significantly negative (t-statistics between −2.04 and −2.85).

[17] The adjustment is to the median investment in the industry in each year, based on the four-digit SIC code. If the four-digit category contains fewer than five observations, I use a three-digit code, and if that contains fewer than five observations, I use a two-digit code. See Lang, Ofek, and Stulz (1996) for a similar industry-adjustment procedure.

[18] The number of lags used in the Newey-West procedure is one less than the number of years for each firm.

Table II

Regressions of Investment Intensity on Expected Volatility for Financially Healthy and Distressed Firms

In Panel A, the dependent variable is firm-specific actual investment intensity, estimated by the ratio of capital expenditures in a given year to PP&E at the beginning of the year. The independent variables are the expected market volatility at the beginning of the year (estimated using a GARCH (1,1) model, as described in Section III) and a set of control variables. In Panel B the dependent variable is firm-specific industry-adjusted investment intensity (based on the median investment intensity in the industry), and the independent variables are the expected industry volatility (estimated by applying a GARCH (1,1) model separately to the average monthly return of each industry, based on two-digit SIC codes) and the control variables. Results are presented separately for financially healthy and distressed firms, where, following Altman's model, firms with Z-scores below 1.81 at the beginning of the year are classified as distressed. The control variables are: firm size, estimated by the natural log of the market value of the firm's total assets (as measured by solving equations (6) and (7)); market-to-book, estimated by equity market value divided by equity book value; leverage, estimated by the ratio of the book value of total debt to book value of total assets; cash flow, estimated by the ratio of operating cash flow to PP&E at the beginning of the year; the NBER recession dummy variable; the default spread, estimated by the yield spread between long-term Baa- and Aaa-rated securities; and the interest rate, measured by the nominal return on 1-month Treasury bills. The table presents regression coefficients and t-statistics, based on Newey–West standard errors, computed over the period 1963 to 2002.

	Panel A: Actual Investment		Panel B: Industry-Adjusted Investment	
	Healthy Firms	Distressed Firms	Healthy Firms	Distressed Firms
Intercept	0.179	0.080	0.025	−0.007
	(22.15)	(8.57)	(5.30)	(−1.22)
Exp. volatility	−2.778[a]	1.833[a]	−0.883[a]	1.144[a]
	(−3.10)	(1.72)	(−2.56)	(2.58)
Log_size	−8.841	−4.957	−2.682	−0.662
	(−11.56)	(−6.83)	(−5.73)	(−1.31)
Market-to-book	0.014	0.015	0.006	0.008
	(4.41)	(7.93)	(4.78)	(9.37)
Leverage	−0.086	0.016	−0.030	−0.010
	(−8.76)	(1.23)	(−4.48)	(−1.25)
Lagged cash flow	0.201	0.052	0.173	0.099
	(7.76)	(2.42)	(11.41)	(6.46)
Recession dummy	−0.010	0.033	0.001	−0.006
	(−2.96)	(3.98)	(0.44)	(−2.07)
Default spread	−1.238	−0.098	−0.045	0.629
	(−3.14)	(−0.14)	(−0.20)	(2.00)
Interest rate	7.799	4.249	−1.343	−0.631
	(10.22)	(3.04)	(−2.93)	(−0.94)
# Observations	40,792	9,353	40,077	9,455
R-square	0.067	0.052	0.034	0.022

[a]Indicates that the difference between the coefficients on expected volatility in the samples of distressed and healthy firms is significant at the 0.01 level.

The results in Table III therefore indicate that the general negative effect of volatility on investment becomes significantly weaker with the level of financial distress. This finding, which is consistent with the results reported in Table II, provides further support for the first risk-shifting hypothesis.

Table III

Regressions of Investment on an Interactive Variable between Expected Volatility and Financial Distress

The dependent variable is firm-specific investment intensity (both actual and industry-adjusted), estimated by the ratio of capital expenditures in a given year to PP&E at the beginning of the year. The independent variables are expected volatility at the beginning of the year (at both the market and industry levels, generated using a GARCH (1,1) model, as described in Section III), the firm's Z-score (as a measure of the level of financial distress), an interactive variable between expected volatility and Z-score, and a set of control variables, as described in Table II. The table presents regression coefficients and t-statistics, based on Newey–West standard errors, computed over the period 1963 to 2002.

	Expected Market Volatility		Expected Industry Volatility	
	Actual Investment	Ind-Adj Investment	Actual Investment	Ind-Adj Investment
Intercept	0.097	0.002	0.074	−0.027
	(13.72)	(0.27)	(10.58)	(−2.64)
Exp. volatility	2.859	4.092	6.362	2.899
	(2.31)	(3.52)	(9.09)	(2.88)
Z-score	0.012	0.008	0.009	0.011
	(9.57)	(6.12)	(7.51)	(5.87)
Exp. volatility∗Z-score	−0.996	−0.950	−0.383	−0.568
	(−2.85)	(−2.75)	(−2.06)	(−2.04)
Log_size	−10.301	−9.132	−7.413	−6.334
	(−20.45)	(−17.53)	(−13.15)	(−11.01)
Market-to-book	0.021	0.024	0.019	0.024
	(19.81)	(20.80)	(19.02)	(15.81)
Leverage	−0.014	−0.028	−0.020	−0.028
	(−1.69)	(−3.27)	(−2.26)	(−2.39)
Lagged cash flow	0.162	0.102	0.178	0.021
	(8.42)	(5.03)	(10.48)	(3.25)
Recession dummy	−0.006	−0.009	−0.008	−0.014
	(−1.68)	(−3.08)	(−3.76)	(−3.57)
Default spread	−0.904	0.575	−1.480	1.485
	(−2.28)	(1.82)	(−5.88)	(3.90)
Interest rate	8.215	−0.135	7.749	0.297
	(10.38)	(−0.21)	(14.31)	(0.36)
# Observations	49,802	49,250	48,905	45,291
R-square	0.121	0.073	0.134	0.074

D.2. Hypothesis 2

Table IV examines whether investments of distressed firms generate less value than investments of healthy firms in the presence of high-expected volatility. I regress a given year's market-adjusted asset return on investment in that year and on an interaction variable between investment and the level of financial distress for subsamples of high- and low-expected volatility.[19] The

[19] To ensure that changes in asset value are not driven by new issues of equity or debt, I exclude firm-years with new issues as follows. Following Baker and Wurgler (2002), I define net equity issue

Table IV

Regressions of Asset Return on an Interactive Variable between Investment and Financial Distress in Periods of Low- and High-Expected Volatility

The dependent variable is the firm's asset return in a given year, as derived from equations (6) and (7). The independent variables are the firm's investment intensity in the same year, the firm's Z-score, an interactive variable between investment intensity and Z-score, and a set of control variables, as described in Table II. Results are presented separately for subsamples of low- and high-expected volatilities at the beginning of the year (at both the market and industry levels, estimated using GARCH models, as described in Table II), divided by the median of the expected volatilities. The results in the "Expected market volatility" columns are based on market-adjusted asset return and investment intensity, and those in the "Expected industry volatility" columns on the equivalent industry-adjusted variables. The table presents regression coefficients and t-statistics, based on Newey–West standard errors, computed over the period 1963 to 2002.

	Expected Market Volatility		Expected Industry Volatility	
	Low-Exp. Volatility	High-Exp. Volatility	Low-Exp. Volatility	High-Exp. Volatility
Intercept	0.407	0.324	0.466	0.315
	(17.83)	(13.45)	(15.19)	(12.71)
Investment	0.576	0.531	0.556	0.230
	(11.27)	(7.61)	(11.57)	(5.11)
Z-score	−0.025	−0.029	−0.048	−0.027
	(−7.98)	(−7.37)	(−7.97)	(−6.33)
Investment$*Z$-score	−0.003	0.051	−0.012	0.050
	(−0.18)	(2.32)	(−0.69)	(2.96)
Log_size	−0.019	−0.027	−0.028	−0.024
	(−10.46)	(−13.87)	(−10.61)	(−12.65)
Market-to-book	0.004	0.001	0.001	0.003
	(2.28)	(0.35)	(0.54)	(1.44)
Leverage	−0.231	−0.266	−0.267	−0.201
	(−8.33)	(−8.70)	(−6.50)	(−6.52)
Lagged cash flow	−0.001	−0.007	0.168	−0.001
	(−0.96)	(−1.21)	(2.78)	(−1.59)
Recession dummy	0.148	−0.047	0.079	−0.040
	(2.56)	(−3.59)	(2.31)	(−2.78)
Default spread	−6.447	1.775	−3.783	−1.974
	(−3.86)	(1.53)	(−1.66)	(−1.68)
Interest rate	−11.582	3.800	−6.014	5.516
	(−3.69)	(1.67)	(−1.41)	(2.27)
# Observations	23,065	24,102	20,507	29,548
R-square	0.059	0.065	0.073	0.051

subsamples are divided by the median expected volatility at both market and industry levels.

as the difference between the change in the book value of equity and retained earnings, divided by the book value of total assets, and net debt issue as the difference between the change in the book value of total assets and the change in the book value of equity, divided by the book value of total assets. Following Korajczyk and Levy (2003), I exclude all firm years when net equity/debt issues represent more than 5% of firm value.

When expected volatility is low, the relation between investment and asset value does not depend on the level of financial distress, as indicated by the insignificance of the interactive variable coefficient. When expected volatility is high, however, the relation between investment and asset value is significantly weaker for distressed firms (t-statistics of 2.32 and 2.96), that is, investments of distressed firms are less valuable during times of high uncertainty.[20] These results support Hypothesis 2, indicating risk-shifting considerations in investment decisions of financially distressed firms.

E. Factors Affecting Risk-Shifting

I examine the effects of several factors that are expected to reduce the incentive or limit the ability of shareholders to increase the firm's risk.

Secured debt. Smith and Warner (1979) argue that securing debt gives bondholders title to pledged assets until the debt is paid in full, and thus limits the ability to substitute assets and shift risk.

Convertible debt. Green (1984) shows that since convertible debt reverses the convex shape of levered equity over the upper range of the firm's value, it eliminates the incentive of shareholders to increase the firm's risk.

Debt maturity. Barnea, Haugen, and Senbet (1980) argue that because the value of short-term debt is less sensitive than long-term debt to changes in a firm's asset volatility, shorter-maturity debt reduces the incentive of shareholders to shift risk.

Regulation. Smith (1986) argues that managers of regulated firms have less discretion over investment decisions than managers in unregulated firms. This implies that deviations from optimal investment policy, including risk-shifting behavior, are less likely to occur in regulated firms.

Managerial incentives. Investment in risk-increasing projects may benefit the firm's shareholders, yet the investment decisions are made by the firm's managers. Although management is assumed to represent the shareholders, managers often have their own set of interests (e.g., reputation concerns, compensation-based incentives, empire-building interests, and risk aversion due to their lack of diversification of firm-specific risk). Thus, risk-shifting behavior is likely to depend on the extent to which managers' and shareholders' interests are aligned.

Growth options. The risk-shifting problem represents a conflict of interest between bondholders and shareholders as to the firm's investment decisions.

[20] Since the results in Table IV are based on a regression of changes in asset value in a specific year on investment intensity in the same year, they may be affected by a potential reverse causality relation between investment and asset return. Hence, to eliminate the possible effect of asset return on investment, I apply a two-stage least squares (2SLS) regression using a set of instrument variables that are expected to explain investment in a given year without being affected by that year's asset return. These include market-to-book, leverage (both measured at the beginning of the year), and lagged cash flow from operations, all found in past studies to be important in explaining firm-level investment intensity (see, for example, Fazzari, Hubbard, and Petersen (1988) and Lang, Ofek, and Stulz (1996)). The results of the 2SLS regression (not reported) are very similar to those reported in Table IV.

Thus, risk-shifting behavior, as any other investment-related agency conflict, is more likely to occur when firms have more investment opportunities. Consistent with this argument, the empirical literature finds that firms with more growth opportunities choose capital structures that mitigate potential agency conflicts (see Smith and Watts (1992), Barclay and Smith (1995a, 1995b), and Rajan and Zingales (1995)).

To test the effects of these factors on risk-shifting behavior I regress investment on an interaction variable between expected volatility and financial distress (similar to the regressions reported in Table III), while adding dummy variables that represent each of the above factors:

$$\begin{aligned} Investment_i = \beta_0 &+ \sum_{j=1}^{J} \beta_j D_{j,i} + \left(\delta_0 + \sum_{j=1}^{J} \delta_j D_{j,i}\right) V_i \\ &+ \left(\rho_0 + \sum_{j=1}^{J} \rho_j D_{j,i}\right) Z_i + \left(\gamma_0 + \sum_{j=1}^{J} \gamma_j D_{j,i}\right) V_i Z_i + \varepsilon_i, \end{aligned} \quad (9)$$

where i is the observation index, D_j is a dummy variable of factor j, V is the expected volatility, and Z is the Altman's Z-score. Since the Z-score is inversely related to the level of distress, a positive γ_j indicates that factor j mitigates the effect of financial distress on the relation between expected volatility and investment.[21] The dummy variables are defined as follows: D_1 equals one if the fraction of the firm's debt that is secured is higher than the sample median, and zero otherwise; D_2 equals one if the firm has convertible debt in its capital structure, and zero otherwise; D_3 equals one if the maturity of the firm's debt is shorter than the sample median, and zero otherwise; D_4 equals one if the firm is regulated, and zero otherwise, where, following Hermalin and Weisbach (1988), I consider public utilities (SIC code 49), airlines and railroads (SIC codes 40–47), and financial institutions (SIC codes 60–69) as regulated industries; D_5 equals one if the percentage of equity owned by the firm's top management is lower than the sample median, and zero otherwise, and is a measure of the association between the interests of shareholders and managers (see, for example, Morck, Shleifer, and Vishny (1988) and Mehran (1995)), where data on managerial ownership are taken from the ExecuComp database;[22] and D_6 equals one if the firm is listed on the NYSE/AMEX, and zero if listed on the Nasdaq, and is a measure of growth opportunities, as Nasdaq firms tend to be smaller with more growth options (see, for example, Schwert (2002)).

[21] The regression includes all components of the interaction variables (that is, the first three summation terms), as otherwise the estimates of the interaction effects may be biased.

[22] Compared to the other measures, the number of observations with data on managerial ownership is relatively small, because of both the shorter period of the ExecuComp data and many missing values. Therefore, to maintain the sample size when including managerial ownership data in the regression, I estimate missing values using the regression imputation method. That is, I regress managerial ownership on the other predictive variables for all cases with no missing values, and then replace the missing values with the fitted values from this regression. The results are robust to other imputation methods.

The regression results reported in Table V suggest that, consistent with the theoretical literature, these factors mitigate risk-shifting behavior. Specifically, in firms with secured debt, in regulated firms, and in firms with less growth options, the level of financial distress has a significant weaker effect on the relation between expected volatility and investment; the t-statistics for these variables range from 2.00 to 3.93. The effects of convertible debt, debt maturity, and managerial incentives are also in the predicted direction, but are not always significant (t-statistics between 0.46 and 2.54).

The results are also meaningful in economic terms. The presence of secured debt in the industry-level test, for example, reduces the effect of financial distress on the relation between expected volatility and investment by 3.5%, which is 0.22 of the standard deviation of investment. Each of the remaining factors mitigates the impact of financial distress by 0.06 to 0.38 standard deviations of investment, and overall, the presence of all factors accounts for 0.98 to 1.22 standard deviations of investment.

F. The Effect of Investment on Firm-Specific Volatility

One of the advantages of focusing on expected *market* volatility, rather than *firm-specific* volatility, is that the latter may capture expected positive risk changes in distressed situations that are not related to risk-shifting behavior (e.g., due to a higher risk of losing employees, clients, partners, new deals, or suppliers). Hence, the volatility of firms in financial distress is expected to rise, regardless of whether managers actively shift the firm's risk. Yet, as risk-shifting behavior is directly associated with a firm's investment decisions, it is interesting to examine how changes in the investment intensity of distressed firms affect their risk.

Table VI shows the results of a linear regression of changes in firm-specific asset volatility in a given year (measured by solving equations (6) and (7)) on changes in investment intensity in the previous year. For financially healthy firms, positive changes in investment intensity reduce firm volatility (although not significantly; t-statistic of -1.38). For distressed firms, however, positive changes in investment intensity increase firm volatility (t-statistic of 2.35). Economically, a one standard deviation increase in the change in investment impacts the change in volatility of distressed firms by 0.27 standard deviations more than that of healthy firms. This finding, which is consistent with the results reported in Tables II and III, provides further evidence of risk-shifting behavior in financially distressed firms.

G. Estimating the Costs of Risk Shifting

Risk-shifting behavior implies a wealth transfer from bondholders to shareholders. To estimate the net costs imposed on bondholders as a result of risk shifting, I use a two-step procedure. In the first step I estimate the sensitivity of debt value to investment of distressed firms in years of high-expected volatility

Table V

Regressions of Investment on Interactive Variables between Expected Volatility, Financial Distress, and a Set of Firm Characteristics

The dependent variable is firm-specific investment intensity in a given year, and the independent variables are expected volatility at the beginning of the year, the firm's Z-score, a set of dummy variables, interactive terms between expected volatility, Z-score, and the dummy variables, and a set of control variables, as described in Table II. The dummy variables are defined as follows. D_1 equals one if the fraction of the firm's debt that is secured is higher than the sample median, and zero otherwise. D_2 equals one if the firm has convertible debt in its capital structure, and zero otherwise. D_3 equals one if the maturity of the firm's debt is shorter than the sample median, and zero otherwise. D_4 equals one if the firm is regulated, and zero otherwise, where public utilities (SIC code 49), airlines and railroads (SIC codes 40–47), and financial institutions (SIC codes 60–69) are considered as regulated industries. D_5 equals one if the percentage of equity owned by the firm's top management is lower than the sample median, and zero otherwise, based on the ExecuComp database. D_6 equals one if the firm is listed on the NYSE/AMEX, and zero if listed on the Nasdaq. The regression equation is specified in equation (9), where the table reports the results for the main interaction terms only. Coefficients and t-statistics, based on Newey–West standard errors, are computed over the period 1963 to 2002.

	Market-Adjusted Data	Industry-Adjusted Data
Intercept	−0.088	−0.102
	(−3.31)	(−1.23)
Exp. volatility	22.964	17.748
	(2.52)	(0.86)
Z-score	0.039	0.023
	(7.63)	(1.11)
Exp. volatility∗Z-score	−6.539	−4.208
	(−3.22)	(−0.87)
D_1∗Exp. volatility∗Z-score: Secured debt	2.092	2.074
	(2.40)	(3.93)
D_2∗Exp. volatility∗Z-score: Convertible debt	3.454	0.586
	(2.54)	(0.86)
D_3∗Exp. volatility∗Z-score: Short-term debt	0.865	1.137
	(0.96)	(1.58)
D_4∗Exp. volatility∗Z-score: Regulation	3.449	3.651
	(2.00)	(2.62)
D_5∗Exp. volatility∗Z-score: Low managerial ownership	3.267	2.213
	(1.83)	(0.46)
D_6∗Exp. volatility∗Z-score: NYSE/AMEX	2.988	1.828
	(3.32)	(3.52)
Log_size	0.581	−1.687
	(0.55)	(−2.27)
Market-to-book	0.011	0.015
	(13.74)	(18.06)
Leverage	−0.001	−0.042
	(−0.11)	(−4.77)
Lagged cash flow	0.012	0.031
	(12.79)	(3.83)
Recession dummy	−0.019	−0.005
	(−1.87)	(−0.80)
Default spread	1.744	1.264
	(2.02)	(2.29)
Interest rate	−1.961	−1.978
	(−1.46)	(−2.19)
# Observations	14,524	14,312
R-square	0.133	0.068

Table VI

Regressions of Changes in Firm-Specific Asset Volatility on Changes in Investment Intensity for Financially Healthy and Distressed Firms

The dependent variable is the change in firm-specific realized asset volatility in a given year, as derived from equations (6) and (7). The independent variables are the change in firm-specific investment intensity in the previous year, and a set of control variables, as descried in Table II. Results are presented separately for financially healthy and distressed firms, where a firm is assumed to be in distress if its Z-score at the beginning of the year is lower than 1.81. The table presents regression coefficients and t-statistics, based on Newey–West standard errors, computed over the period 1963 to 2002.

	D (volatility)	
	Healthy Firms	Distressed Firms
Intercept	0.022	0.009
	(3.80)	(0.41)
D (investment)	−0.029[a]	0.115[a]
	(−1.38)	(2.35)
Log_size	2.496	5.400
	(3.86)	(2.72)
Market-to-book	−0.003	0.006
	(−2.78)	(1.22)
Leverage	0.004	−0.049
	(0.52)	(−1.81)
Lagged cash flow	−0.134	−0.076
	(−7.96)	(−2.61)
Recession dummy	−0.018	−0.007
	(−4.17)	(−0.30)
Default spread	−4.418	−6.123
	(−11.53)	(−3.84)
Interest rate	6.651	10.656
	(8.31)	(2.97)
# Observations	35,773	8,308
R-square	0.009	0.006

[a]Indicates that the difference between the coefficients on expected volatility in the samples of distressed and healthy firms is significant at the 0.01 level.

by the slope coefficient of the following regression:

$$\%\Delta V_D = \gamma_0 + \gamma_1 Investment + \varepsilon, \tag{10}$$

where V_D is the firm's debt value, measured by the difference between asset value (estimated by solving equations (6) and (7)) and equity value.[23] Since investing in risky projects reduces the value of debt in distressed firms, γ_1 is expected to be negative.

In the second step I estimate the investment distortion in distressed firms during periods of high volatility. As reported in Table II, there is a positive relation between expected volatility and investment of distressed firms. Hence, in years with high-expected volatility, the average investment intensity of distressed firms (relative to healthy firms) is expected to be higher than that over

[23] As in the asset return tests, to ensure that changes in the market value of debt are not driven by new issues of equity or debt, I exclude firm years with significant equity/debt issues.

Table VII

Estimation of Costs of Risk-Shifting

Panel A shows results of regressions of the percentage change in debt value in a given year on investment intensity in the same year and a set of control variables (as descried in Table II) in a subsample of financially distressed firms (i.e., Z-scores below 1.81). Debt value is measured by the difference between asset value (estimated by solving equations (6) and (7)) and equity value. Firm-years with significant equity and debt issues are excluded (as discussed in Section III). Results are presented separately for equal-sized subsamples of low- and high-expected market volatilities estimated using a GARCH model, as described in Table II. The panel presents regression coefficients and t-statistics, based on Newey–West standard errors, computed over the period 1963 to 2002. Panel B estimates the risk-shifting costs by multiplying the coefficient on investment from Panel A by the overinvestment of distressed firms in high-volatility periods, as defined in equation (11).

Panel A: Effect of Investment on Debt Value

	Low-Exp. Volatility	High-Exp. Volatility
Intercept	−27.598	3.367
	(−6.05)	(2.07)
Investment	12.591	−8.563
	(1.32)	(−2.39)
Log_size	1.418	−0.315
	(2.69)	(−1.68)
Market-to-book	−0.064	0.119
	(−0.06)	(0.34)
Leverage	48.954	−5.226
	(5.92)	(−1.73)
Lagged cash flow	−7.791	−0.025
	(−6.98)	(−0.04)
# Observations	3,051	3,440
R-square	0.030	0.004

Panel B: Costs of Risk-Shifting

	Market-adjusted
Average investment of distressed firms over the entire sample period	−5.32%
Average investment of distressed firms in high-volatility periods	−4.58%
Overinvestment in high-volatility periods	0.74%
Sensitivity of debt value to investment in high-volatility periods	−8.563
Costs of overinvestment in high-volatility periods	−6.38%

the entire sample period. I refer to this difference as the *overinvestment* of distressed firms in periods of high volatility.

The costs imposed on bondholders are therefore measured by multiplying the estimate of the overinvestment by the sensitivity of debt value to investment in high-volatility periods:

$$Costs = \gamma_1[(inv_d - inv_h)_{high\ volatility\ years} - (inv_d - inv_h)_{entire\ sample\ period}], \qquad (11)$$

where inv_d and inv_h are the averages of investment intensity in distressed firms and healthy firms, respectively.

Panel A of Table VII shows the results of the first step. As expected, when volatility is high, investments of distressed firms have a negative effect on the value of debt, with a coefficient (γ_1) of −8.56 and a t-statistic of −2.39. This result is consistent with the weaker effect of investment on asset value in distressed firms during periods of high uncertainty, as reported in Table IV. In periods of low-expected volatility, no significant relation is found between investment and debt value. Panel B shows that while distressed firms generally invest less than healthy firms, their relative investment is higher in the high-volatility subsample (overinvestment of 0.74%). Hence, based on equation (11), the value of debt in distressed firms is reduced by approximately 6.38% as a result of overinvestment during times of high volatility.

IV. Robustness Tests

I replicate the regressions reported in Tables III and IV, which address the two risk-shifting hypotheses, using alternative estimation methods and using alternative measures of the extent of financial distress.

Estimation method. The results in Tables III and IV are based on OLS estimation, where the standard errors are corrected for heteroskedasticity and serial correlation using the Newey and West (1987) procedure. For robustness, I examine the results using two alternative methods. The first one is a feasible generalized least squares (FGLS) regression, allowing for a heteroskedastic and firm-specific autocorrelation variance-covariance matrix of the errors. The second one is a fixed year and industry effects regression. This regression includes dummy variables for each year and two-digit SIC code in the sample, where White (1980) standard errors are used to adjust for heteroskedasticity. The results based on both the FGLS estimation and the fixed year and industry effects (reported in Table VIII) remain significant, and are even stronger in some cases, supporting both risk-shifting hypotheses.

Financial distress measures. Instead of Altman's Z-score, I use two other common measures. The first one is based on the Zmijewski (1984) probit model for predicting bankruptcy.[24] The second one, known as the KMV approach (see Crosbie and Bohn (2002) and Leland (2004)), is built on the default model of Merton (1974). Specifically, as the Black–Scholes model implies, the probability of default (which is equivalent to the probability of not exercising a European call option) is given by $1 - N(d2)$, calculated using the inputs of equations (6) and (7).[25] The results are reported in Table VIII. Regression results based on the Zmijewski model are very similar to those based on the Z-score for both

[24] Zmijewski's model for predicting bankruptcies is: X (−4.3–4.5(Net income/Total assets) + 5.7(Total liabilities/Total assets) − 0.004(Current assets/Current liabilities), where X is a standard normal variable, and the probability of bankruptcy is given by the value of the cumulative normal distribution function at point X.

[25] Although this measure is found to be a good predictor for future bankruptcies (see Hillegeist et al. (2004)), we should note that it has several limitations. First, the Black–Scholes model assumes a risk-neutral probability (explaining why only the risk-free rate, and not the asset's drift, appears in the model), while in practice the probability of default is a function of the actual probability distribution of future asset values. Second, the model assumes a single class of debt with a single maturity date, while typically a firm's debt is composed of several types of bonds with different maturity horizons.

Table VIII

Robustness Tests

Panel A and Panel B replicate the regression results reported in Tables III and IV, respectively (referred to as "base results"), using two alternative estimation methods and two alternative measures of financial distress. The estimation methods include a feasible generalized least squares (FGLS) regression, allowing for a heteroskedastic and firm-specific autocorrelation variance-covariance matrix of the errors, and a fixed year and (two-digit SIC code) industry effects regression, while using White heteroskedasticity-consistent standard errors. The measures of financial distress are based on the Zmijewski model and the KMV model (as described in Section IV). In Panel A firm-specific investment intensity is regressed on an interaction variable between expected volatility and financial distress (*Z*-score) and on a set of control variables (size, market-to-book, leverage, lagged operating cash flow, the NBER recession dummy variable, default spread, and interest rate), where only the coefficients and *t*-statistics of the interactive variable are reported. In Panel B asset return is regressed on an interaction variable between investment intensity and financial distress and on the control variables, where only the coefficients and *t*-statistics of the interactive variable are reported. The results are computed over the period 1963 to 2002.

Panel A: Effect of the Interaction between Expected Volatility and Financial Distress on Investment

	Expected Market Volatility		Expected Industry Volatility	
	Actual Investment	Ind-Adj Investment	Actual Investment	Ind-Adj Investment
Base results	−0.996	−0.950	−0.383	−0.568
	(−2.85)	(−2.75)	(−2.06)	(−2.04)
Estimation method				
FGLS	−0.570	−0.267	−0.733	−0.319
	(−2.67)	(−1.97)	(−5.75)	(−2.72)
Year and industry effects	−0.711	−0.857	−0.188	−0.752
	(−2.90)	(−3.23)	(−1.71)	(−2.47)
Financial distress measure				
Zmijewski's model	−8.262	−6.660	−3.362	−3.705
	(−2.65)	(−2.39)	(−1.83)	(−2.53)
KMV model	−6.175	−4.284	−14.675	−4.249
	(−1.97)	(−1.69)	(−1.70)	(−2.44)

Panel B: Effect of the Interaction between Investment and Financial Distress on Asset Return

	Expected Market Volatility		Expected Industry Volatility	
	Low-Exp. Volatility	High-Exp. Volatility	Low-Exp. Volatility	High-Exp. Volatility
Base results	−0.003	0.051	−0.012	0.050
	(−0.18)	(2.32)	(−0.69)	(2.96)
Estimation method				
FGLS	−0.014	0.050	−0.044	0.071
	(−0.98)	(2.61)	(−1.21)	(3.32)
Year and industry effects	−0.005	0.051	−0.013	0.046
	(−0.30)	(2.31)	(−0.72)	(2.73)
Financial distress measure				
Zmijewski's model	−0.067	0.319	−0.059	0.286
	(−0.36)	(2.51)	(−0.66)	(2.02)
KMV model	0.103	0.858	0.233	0.792
	(0.37)	(5.79)	(0.92)	(5.10)

hypotheses. The results based on the KMV model are somewhat weaker than those based on the Z-score when testing the first hypothesis (Panel A), but are much stronger when testing the second hypothesis (Panel B). These results suggest that the main findings of this study are not sensitive to the measure of financial distress.

V. Conclusions

This paper provides empirical evidence of risk-shifting behavior in financially distressed firms by examining the relation between investment and volatility. While the option to delay investment decisions implies that volatility has a negative effect on investment, shareholders' risk-shifting incentives produce the opposite effect. I use a three-date model that captures both effects to show that the latter effect can be dominant for firms in financial distress.

The model implies that risk-shifting behavior is consistent with two main results. The first is that there is a weaker negative relation, or even a positive relation, between volatility and investment intensity in distressed firms. The second is that investments of distressed firms are expected to generate less value during times of high uncertainty. Empirical tests of the model's implications using 40 years of data indicate risk-shifting considerations are present in the investment policies of distressed firms.

I also find that risk-shifting behavior is affected by various factors associated with the incentive and ability of shareholders to shift additional firm risk to bondholders. These include characteristics of the debt (mainly, whether secured or not), growth options, regulation, and managerial incentives. Measurement of the costs imposed on bondholders as a result of risk shifting indicates that the value of debt in distressed firms is reduced by approximately 6.4% due to overinvestment in high-volatility periods.

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