How Important is Financial Risk?[☆,☆☆]

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Abstract

We explore the determinants of equity price risk of non-financial corporations. Operating and asset characteristics are by far the most important determinants of risk. For the median firm, financial risk accounts for only 15% of observed stock price volatility. Furthermore, financial risk has declined over the last three decades indicating that any upward trend in equity volatility was driven entirely by economic risk factors. This explains why financial distress (as opposed to economic distress) was surprisingly uncommon in the nonfinancial sector during the recent crisis even as measures of equity volatility reached unprecedented highs.

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I. Introduction

The recent financial crisis has brought significant attention to the effects of financial leverage. Despite the seizing of capital markets during the crisis, problems in the U.S. non-financial sector have been relatively minor compared to the distress in the financial sector. For example, non-financial bankruptcies have been limited despite the fact that the economic decline is the largest since the great depression of the 1930s. In fact, bankruptcy filings of non-financial firms have occurred mostly in U.S. industries that faced fundamental economic pressures prior to the financial crisis (e.g., automotive manufacturing, newspapers, and real estate). This surprising fact raises the question, "How important is financial risk for non-financial firms?"

While the study of leverage and financial risk is ubiquitous in financial economics there is little work on fundamental determinants of risk at the firm level. Some older studies dating back as far as Rosenberg and McKibben (1973) find that firm operating and financial characteristics such as size, profitability, and leverage are important for explaining equity risk factors. Christie (1982) documents a strong relation between changes in stock price volatility and financial leverage. However, Schwert (1989) finds that leverage explains a relatively small part of the movements in stock volatility. Despite these differences in findings, the precise determinants of equity market volatility remain relatively unexplored.

Using a more recent and comprehensive sample of U.S. firms we re-examine the issue of financial risk in light of the financial crisis of 2008. The primary result of our analysis is surprising: measures of implied financial risk are small for most firms. Instead, factors determining economic risk for a typical company appear to explain the vast majority of the variation in equity volatility. Only for a small fraction of the most highly levered firms in our sample are financial risks greater than economic risks. We find that our implied measures of financial risk that take into account all effects of financial policy on risk are much lower than would be suggested by just measuring total debt relative to firm value. For example, actual financial (market) leverage[5] is about 1.50 compared to our implied estimates of between 1.03 and 1.11 (depending on model specification and estimation technique) in our sample covering 1964 to 2009. Moreover, using the volatility decomposition method described in Choi and Richardson (2009), we find that asset volatility accounts for 84.7% (67.6%) of total volatility for the median (average) firm in our full sample. This result suggests that firms manage financial risk by undertaking financial policies that lower exposure to relatively low levels. These policies likely include choosing (and adjusting) financial variables such as debt levels, debt maturity, dividend policies, or cash holdings in response to realized or anticipated business risks (see, for example, Acharya, Almeida, and Campello (2007)). In addition, firms may utilize explicit financial risk management techniques such as the use of financial derivatives, contractual

[5]Market leverage is defined as the market value of equity plus total debt (net of cash) as a percent of the market value of equity. Thus a value of 1.0 represents no financial leverage.

arrangements with investors (e.g. lines of credit, call provisions in debt contracts, or contingencies in supplier contracts), special purpose vehicles (SPVs), or other alternative risk transfer techniques that are typically hard to observe. For example, we estimate the impact of interest rate derivative usage on a sub-sample of our firms and find that derivative usage is associated with significantly lower financial risk.

Compared to extant research, this paper takes a somewhat different tack by focusing on the decomposition of risk into two components: economic and financial. We seek to understand the determinants of equity price risk at the firm level by considering total risk as the combination of risks inherent in the firms operations (i.e., economic or business risks) and risks associated with financing the firms operations (i.e., financial risks). We then attempt to assess the relative importance of economic and financial risks and the implications of these risks on financial policy.

Our goal of identifying the important determinants of equity price risk (volatility) relies on viewing financial policy as transforming asset volatility into equity volatility via financial leverage. Thus, we consider financial leverage as the wedge between asset volatility and equity volatility. For example, in a static setting, financial leverage magnifies operating profits available to equityholders. Because financial policy is determined by owners (and managers), we are careful to examine the effects of firms' asset and operating characteristics on financial policy.

For our study, we utilize a large sample of non-financial firms in the United States from 1964 to 2009. We conduct two primary types of empirical analysis to assess sources of equity volatility. First, we allow economic risk to be a determinant of financial policy in the structural framework of Leland and Toft (1996). An advantage of this structural model approach is that we are able to account for the possibility of both financial and operating implications of some factors (e.g., dividends), as well as the endogenous nature of the bankruptcy decision and financial policy in general. A disadvantage of this approach is that our results could depend on the form of the structural model. Our second primary method takes a time-series approach to examining determinants of equity volatility by estimating an augmented exponential GARCH (EGARCH) model (Nelson (1991)) that allows the long-run component of risk to be determined by firm-specific business and financial risk factors.[6] The primary advantage of this model is that it incorporates known features of equity price dynamics, such as volatility clustering. A potential disadvantage of this approach is that there is no structural interaction between business and financial risks.[7]

The effects of our economic risk factors on equity volatility are often highly statistically sig-

[6]This model is similar to the approach employed by Choi and Richardson (2009) and allows for nearly direct comparisons to their results.

[7]To a large degree these modeling trade-offs are irrelevant for our conclusions since the primary results of our analysis are also evident in univariate sorts on firm volatility as well as from estimates of simple panel regressions. However, the more careful analysis is required to determine if the results are driven by endogeneity, volatility clustering, etc.

nificant, with predicted signs, and the magnitudes of the effects are substantial. We find that the volatility of equity returns decreases with the size and age of the firm. This finding is intuitive since large and mature firms typically have more stable lines of business, which should be reflected in the volatility of equity returns. Larger and older firms are also more likely to have risk management programs which tend to lower financial risks (see Bartram, Brown, and Conrad (2011)). Equity volatility tends to decrease with capital expenditures. Consistent with the predictions of Pástor and Veronesi (2003), we find that firms with higher profitability and lower profit volatility have lower equity volatility. Among the variables we consider, the effects on equity volatility of firm size, profit volatility, and dividend policy stand out as most important.

Of particular interest is our finding that measures of implied financial leverage declined significantly between the late 1970s and the late 1990s. Over this same period measures of equity price risk (such as idiosyncratic risk) increased. In fact, measures of implied financial leverage from our structural model settle near 1.0 (i.e., no leverage) by year 2000. Our evidence suggests that there are several reasons for this trend. First, total debt ratios for non-financial firms have declined steadily over the last 30 years, so our measure of implied leverage should also decline. Second, firms have significantly increased cash holdings, so measures of net debt (debt minus cash and short-term investments) have also declined. Third, the composition of publicly traded firms has changed with more risky firms (especially technology-oriented firms) becoming publicly listed. These firms tend to have less debt in their capital structure. Fourth, firms appear to be undertaking a variety of financial activities (e.g., risk management with derivatives) that have reduced financial exposures. For example, we document that the aggregate interest expense net of changes in cash holdings has declined to zero over the last thirty years in a way that closely mimics the decline in our implied leverage measures.[8]

We conduct a battery of additional tests to examine the robustness of our results. We repeat our analysis with a reduced-form model that imposes minimum structural rigidity on our estimation and obtain results that are very similar to those from the structural model and time-series model. We undertake a simulation study of the structural model to identify any inherent biases resulting from our specification and find that any biases related to misspecification of the asset volatility function are likely to be small. However, we find some evidence that misspecification of debt levels in the Leland-Toft model could bias down our estimates of leverage. We make bias adjustments to assess the effects of this problem and show that we still observe low and declining financial risk over the last three decades. We also estimate the models on various subsamples of firms (e.g., partitioned by debt levels) and find that estimated parameters and implied risk measures follow expected (and intuitive) patterns.

[8]The decline in this measure is driven by a combination of lower debt, lower interest rates and increased cash holdings. We cannot say if this is an optimal response to changes in other firm characteristics (such as higher asset volatility), but it is a dramatic and systematic shift.

The paper is organized at follows. Motivation, related literature, and hypotheses are reviewed in Section II. Section III describes the models we employ followed by a description of the data in Section IV. Empirical results for the Leland-Toft model and the time-series model are presented in Section V. Section VI considers robustness tests. Section VII concludes. An Internet Appendix includes details of many robustness tests and alternative specifications.

II. Motivation and Hypotheses

Economic risk can be thought of as uncertainty regarding the value of the firm's assets and the future profits of the company. These are the "real" risks a company faces and include uncertainty about the market for a firm's products, the cost and availability of factor inputs to production, and the risks of competition and innovation, among others. Prior research has modeled this type of uncertainty in various ways. For example, in the setting of Merton (1974), economic risk is modeled as uncertainty in the underlying asset value of the firm. Other research models economic risk as uncertainty about the level of firm profitability. Empirically it may be important to consider risks related to both a firm's assets and a firm's profitability. For example, consider two firms with identical profit characteristics, but the assets of one firm are composed of a greater proportion of intangible assets. The firm with fewer tangibles may be riskier if the recovery value upon bankruptcy is lower. For this reason, we characterize the qualities of both assets and profitability in our analysis.

We hypothesize that larger firms are likely to have a more diversified customer base and a longer operating history. Both of these features suggest that larger firms should be less risky. As noted already, tangible assets (plant, property, and equipment) serve as a proxy for the 'hardness' of a firm's assets and may lose less of their value upon bankruptcy. (Gilson (1997)) The ratio of capital expenditures to total assets serves as a measure of a capital intensity as well as growth potential.[9] Higher capital intensity is typically associated with higher operating leverage (i.e., a higher proportion of fixed costs), whereas higher growth opportunities imply that firm value depends more on distant cash flows. Both of these characteristics magnify variations in operating profits.

We characterize firm profitability in two ways. First, we consider the level of profitability (operating margin before depreciation) as a measure of economic risk. A firm with a high operating margin is likely to be less risky for several reasons. High profit margins may be a sign of low product market competition. In addition, financial distress is often triggered by an adverse economic shock. As such, a more profitable firm is likely to be far from financial distress and, therefore, less likely to have equity returns magnified by variations in expected bankruptcy costs. Higher profit levels may also suggest that more of a firm's value comes from relatively near-term cash flows which are

[9] We also consider the market-to-book ratio as a measure of growth potential.

likely to be less uncertain. Second, we consider the volatility of profits. As discussed above, Pástor and Veronesi (2003) show the direct relation between profit risk and equity price risk in a setting where investors must learn about the long-run profitability of a company.

We also use a variety of firm-specific characteristics to describe the financial risks a firm's shareholders face. The most fundamental financial risk stems from debt financing. In a perfect markets setting, debt has a direct effect on volatility of equity returns and, therefore, on our measure of total firm risk. However, theoretical research suggests that firms choose the optimal amount of debt as a function of economic risk, so the actual relation is again an empirical issue. We also consider cash holdings since they act as liquid reserves and hypothesize that firm risk should have a negative relation with cash holdings if cash acts as 'negative debt.' On the other hand, Opler, Pinkowitz, Stulz, and Williamson (1999) and Acharya, Almeida, and Campello (2007) find that cash is not just negative debt, but instead serves the role of precautionary savings to ensure against underinvestment. The maturity of debt used by firms may also determine the level of firm risk. For example, firms using relatively more short-term debt may be more exposed to interest rate fluctuations and roll-over risk and, therefore, have higher levels of total risk.

Dividend policy can also affect the level of firm risk for several reasons. First, Pástor and Veronesi (2003) show that firms not paying dividends have higher return volatility than dividend payers. For dividend payers, equity value depends less on terminal firm value and more on (relatively) near-term dividends, which are less sensitive to operating performance (i.e., average profits). Dividends may also serve as a signaling device for managers that wish to communicate strong prospects, and thus lower risk, for their companies. Intuitively, dividends are more commonly paid by mature firms with more stable lines of business and fewer growth opportunities. In this case, dividends act more as an indicator of economic risk than financial risk. On the other hand, large more mature firms that pay dividends are also more likely to have sophisticated treasury operations that would carefully manage financial risk (e.g., with derivatives).

III. Models of Firm Risk

The relation between financial and economic risk is likely to be affected by the endogenous nature of financial decision making (e.g., firms with low economic risk can afford higher debt levels). To account for the importance of firm-specific characteristics on financial decision making, we utilize two general empirical approaches in our analysis as well as variants on these methods. Our first approach employs the structural model of Leland and Toft (1996). Our second approach explicitly considers the well-documented time-series properties of equity volatility by incorporating firm-specific characteristics into an augmented EGARCH model.

A. Leland-Toft Model

The Leland and Toft (1996) model (henceforth, the LT model) provides a specific structural form for describing total firm risk. More specifically, the LT model builds upon the observation made by Black and Scholes (1973) and Merton (1974) that the equity of a firm resembles a call option on the firm's assets. The LT Model generalizes the Merton model, in several ways. Bankruptcy can occur anytime (similar to Black and Cox (1976)). In addition, bankruptcy is assumed to be an endogenous event triggered by equity holders to maximize equity value. The model allows a finite average maturity (T) for debt, tax deductible coupon payments (C), default costs (α), and net cash payouts (δ) to security holders. As such, the LT framework combines the Merton model with both trade-off theory (i.e., tax benefits versus bankruptcy costs related to leverage) and agency theory (e.g., asset substitution).

To estimate the model, we minimize the squared deviations of predicted equity volatility (σ_E) from actual volatility. Following the LT model, we define

$$(1) \quad \sigma_E = l(\sigma_A) * \sigma_A$$

which describes how asset volatility (σ_A) is transformed into equity volatility by a function characterizing financial leverage, $l(\cdot)$, that is also a function of σ_A. We parameterize σ_A in a straightforward, but admittedly ad hoc, fashion as an exponential function of economic risk variables to ensure positive values of σ_A. In the LT model

$$(2) \quad l(\sigma_A) = [1 + \frac{D(V; VB; T)}{E(V; VB; T)}]k(\sigma_A)$$

where D, E, and V are, respectively, the market value of debt, equity, and the firm's assets; VB is the endogenous bankruptcy trigger. Note that $k(\sigma_A)$ is analogous to $N(d_1)$ in the Merton (1974) model. Section A of the Internet Appendix provides an in-depth discussion of the LT Model as well as closed-form expressions for the model's parameters.

B. Augmented EGARCH Model

While the LT model can be estimated with time-series, cross-sectional, or panel data, the LT model does not incorporate well-documented time-series features of equity return volatility such as autoregressive conditional heteroskedasticity (volatility clustering). In addition, LT model misspecification could lead to biased estimates of implied leverage and its determinants (discussed in more detail below). Consequently, we take an alternative and completely independent approach to assessing the role of various firm characteristics. Specifically, we estimate an 'augmented' EGARCH model (see, Nelson (1991)) where volatility depends on return history and a set of firm characteristics ($X_{i,t}$). The general model takes the form

$$(3) \quad r_{i,t} = \sigma_{i,t}\varepsilon_{i,t}$$

$$(4) \quad \ln(\sigma^2_{i,t}) = X_{i,t}\delta + \beta \ln(\sigma^2_{i,t-1}) + \alpha(|\varepsilon_{i,t-1}| - \mathrm{E}|\varepsilon_{i,t-1}|) - \gamma\varepsilon_{i,t-1}$$

where $r_{i,t}$ is the return for stock i in period t; α, β, and γ are typical EGARCH scalar parameters to be estimated; the vector δ represents estimated coefficients for the firm characteristics (including a constant term). We estimate the model using stacked quarterly data. A major advantage of this model is that it allows firm-level characteristics to determine dynamic volatility across both firms and time.

IV. Data

Our sample construction begins with firms that have accounting data in the CompuStat database for any year between 1964 and 2009 and that have at least 125 non-zero daily stock returns in the CRSP database during the year of the accounting data. We exclude utilities and financial services companies (industries 20 and 29 in the Fama-French classification of 30 industries) because these firms are regulated and may therefore have different risk-taking incentives. In addition, we apply a variety of screens to our sample to focus on only liquidly traded firms in periods of normal operations. The Internet Appendix provides a detailed discussion of these screens and a table of their effect on the sample size. It also provides a detailed discussion of variable construction. Overall, our sample covers the vast majority of the market value of U.S. firms excluding financials and utilities – an average of 90.7% of total market capitalization. Our proxy for firm risk is the volatility of common stock returns (the annualized standard deviation of daily returns).[10]

[Insert Table 1 About Here]

Table 1 provides summary statistics for our economic and financial risk variables, along with market equity volatility. In general, we observe significant variation for all variables of interest. Table 1 also reports the correlations between the variables of interest. The correlation coefficients between equity volatility and economic risk variables are typically large in absolute value (capital expenditures is the exception). For financial risk variables, however, the results are not nearly as strong as economic risk variables and sometimes counterintuitive. For example, cash holdings are positively related to equity volatility (consistent with the precautionary savings motive). Surprisingly, equity volatility is essentially uncorrelated with the leverage measures, and dividends are strongly negatively related to equity volatility. This finding is consistent with the hypothesis that dividends are paid by more mature firms with more stable cash flows and inconsistent with dividends increasing financial leverage (i.e., net debt) and thus total risk. Another interesting finding is that financial risk variables are often highly correlated. For example, the pairwise correlations between net debt, debt maturity, and coupon rate are all greater than 0.40.

[10]We have also conducted our primary analysis using weekly and monthly returns and find very similar results.

V. Results

A. Quartiles

Table 2 provides summary statistics for variables by equity volatility quartiles allowing us to obtain a feel for the economic significance of the correlations presented in Table 1. The results are quite dramatic and foreshadow the results of the multivariate estimations presented in the remainder of the paper. When we examine the differences in values between the first and fourth quartile, we see that low risk firms are about 7 times as large (in terms of total assets) and three times as old as high risk firms. In addition, low risk firms have 50% more tangible assets than high risk firms. Low risk firms are highly profitable, whereas high risk firms do not break even. Similarly, profit volatility of low risk firms (0.021) is a very small fraction of that of high risk firms (0.160). The dividend yield of low risk firms is an order of magnitude greater than that of high risk firms. In contrast, there is no clear relation between equity volatility and capital expenditures.

[Insert Table 2 About Here]

For financial characteristics, there are few obvious patterns across equity volatility quartiles. Specifically, total debt, net debt, and cash as a percent of market capitalization exhibit no obvious trends across volatility quartiles. Debt maturity is slightly lower for high risk firms, as is the coupon rate. Only total debt as a percent of total assets shows a clear (in this case, upward) trend as risk increases. In sum, these results suggest that firm characteristics related to economic risks are more important than financial characteristics for explaining cross-sectional variation in equity volatility.

B. LT Model Estimation and Results

We now turn to estimating the LT model discussed above. Below we describe the exact specifications as well as the results of the estimation. We estimate both pooled regressions and Fama-MacBeth style regressions. Pooled regressions do not assume time-series independence and are based on full information maximum likelihood. Therefore, they do not suffer from a direct errors-in-variables problem, an issue that is known to plague two-pass procedures like Fama-MacBeth. However, unlike the Fama-MacBeth method, pooled regressions require the estimation of the error covariance matrix of the panel. This estimation is usually done by imposing an arbitrary structure on cross-correlation and heteroskedasticity or by simply assuming a time-invariant covariance matrix. In contrast, the Fama-MacBeth procedure suffers from the errors-in-variables problem, but it allows estimation of the cross-section without imposing any structure on the covariance matrix. (Fama and MacBeth (1973)) In general, the pooled regressions are likely to have more power if the relations between variables are stable, but potentially lead to poor inference if the relations between variables have unmodeled time trends. We subsequently examine trends in the Fama-MacBeth parameter estimates and find that some values appear to exhibit time trends (for example, the effect of firm age). Thus we caution the reader when interpreting the pooled estimate results. However, the methods usually provide similar results.

1. LT Model Empirical Specification

Estimating the LT model requires some additional assumptions. First, we set asset value in each firm-year to 100 and scale other variables to this value when necessary. This standardization simplifies the numerical estimation. We utilize the 10-year constant maturity U.S. Treasury yield (compiled by the Federal Reserve Board) as a proxy for the risk-free rate, r. For the corporate income tax rate, τ, we use the statutory rate for the highest income group as reported by The Tax Foundation.[11] We assume a value of 0.4 for α, the fraction of firm value lost in bankruptcy.

For other model inputs, we parameterize the values using firm-specific data. Most importantly, we specify

$$\begin{aligned}\sigma_A = &\exp\{\beta_0 + \beta_1 \log(Size) + \beta_2 \log(Age) + \beta_3 TangibleAssets + \beta_4 Capex \\ &+ \beta_5 Profitability + \beta_6 ProfitVolatility + \beta_7 DividendYield\}\end{aligned} \tag{5}$$

where the β_i parameters are estimated coefficients.[12] We parameterize debt maturity to be between 1 and 10 years by defining

$$T = 1 + 9\,\frac{LongTermDebt + PreferredStock}{TotalDebt}. \tag{6}$$

However our results are not meaningfully affected by this choice of maximum maturity. The face value of all outstanding debt (P) is calculated as net book leverage adjusted by a $LeverageFactor$ to take into account endogenous financial policies not observed by the econometrician, so that

$$P = LeverageFactor * (TotalDebt - Cash) \tag{7}$$

Consequently, the estimation will adjust the $LeverageFactor$ (and other parameters) so as to minimize the squared error of equity volatility as specified by the model. A $LeverageFactor$ greater than 1.0 would indicate that firms have more effective financial leverage than implied by the net debt ratio, perhaps because of off-balance sheet financing such as operating leases, pension liabilities, or structured investment vehicles (SIVs). Recent research suggests that reported debt levels may understate effective financial leverage (see, Cornaggia, Franzen, and Simin (2011); Shivdasani and Stefanescu (2010)) and thus we might reasonably expect a leverage factor greater than one. In contrast, a $LeverageFactor$ less than 1.0 would indicate that firms have less effective financial leverage than implied by the net debt ratio, perhaps because of various financial risk management policies such as cash management, insurance, dynamic capital structure, use of financial derivatives,

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[11] See http://www.taxfoundation.org/taxdata/show/2140.html

[12] A downside to our ad-hoc specification for asset volatility is that unmodeled determinants of volatility might get absorbed into the constant. In the Internet Appendix we discuss estimating the model with a constant term in the leverage equation as an alternative.

or so-called ‘alternative risk transfer’ techniques.[13]

We use the previously defined variables to define our proxy for the coupon rate (C) so that

$$C = \frac{InterestExpense + PreferredDividends}{TotalDebt} \tag{8}$$

These observable variables allow for the calculation of all other variables in our optimization problem described in Appendix A.[14] Specifically, we note that this estimation procedure calibrates the model in a way that allows for the endogenous nature of the bankruptcy decision and financial policy in general. When estimating the LT model using the Fama-MacBeth method, the optimization converges in all years except 1999, 2008, and 2009; consequently, we exclude those years from the Fama-MacBeth part of the analysis.

2. LT Model Results

Table 3 reports the results of pooled and Fama-MacBeth estimations for the LT model. The pooled sample results show that all the economic risk factors we consider are statistically significant explanatory variables for equity volatility at better than the 0.001 confidence level. As suggested by the previous analysis, the volatility of equity decreases with firm size and age. Lower profitability and higher profit volatility increase equity volatility. More tangible assets and capital expenditures are associated with lower volatility. Dividend yield is negatively related to equity volatility. For Fama-MacBeth regressions, the results for firm characteristics are mostly similar in sign and significance. The exception is for tangible assets which is not statistically significant. Marginal effects show that some factors have stronger effects on risk than others. In both specifications, firm size, profit volatility, and dividends exhibit the greatest effects. These effects are quite economically large. For example, the marginal effect of 0.102 for profit volatility in the Fama-MacBeth specification indicates that as we move from the lower quartile breakpoint to the upper quartile breakpoint the equity risk of a firm increases by about 50%, *ceteris paribus*.

[Insert Table 3 About Here]

An important advantage of the LT specification is that it allows for the empirical appraisal of the importance of financial leverage through the estimation of the $LeverageFactor$. For both estimations, the value of the $LeverageFactor$ is low: 0.10 in the pooled specification and 0.28 in the Fama-MacBeth specification. The low values are surprising and suggest that the actual relation between financial leverage and equity volatility is substantially lower than would be inferred from a casual observation of the total debt ratio. We emphasize that the small value is not the result

[13] For example, an industrial firm with a financing arm may create a separate legal entity that reduces financial exposure for the firm even though the reporting of the entity’s debt is consolidated on the firm’s balance sheet.

[14] In the optimization we use model estimates for equity value. Since actual values tend to be higher than model values, implied leverage would be even lower if we used actual equity values.

of low statistical power since the coefficient is significantly different from zero (and 1.0) at better than the 0.001 level.

Table 3 also reports estimated values for asset volatility (σ_A) and implied financial leverage (l). The models do a good job of matching the cross-sectional variation of equity volatility as evidenced by the standard deviation of model estimates of σ_A. The values of 0.160 to 0.175 are in the range of the observed standard deviation of equity volatility (0.245). The values for market leverage (1.029 and 1.105) are close to 1.0. This result derives from the low estimated values for the $LeverageFactor$. The implication of this result is that little of observed equity price risk can be attributed to financial leverage, and thus, the implied levels of financial risk are quite low. In addition, about a quarter of firms have implied leverage below 1.0 which suggests that these firms actually reduce their total risk with financial policy (e.g., with cash holdings in excess of debt that can serve as contingency reserves during periods of financial stress). We note that this finding is consistent with the distribution of net debt (not reported). Overall, our estimates of mean asset volatility (0.475 and 0.396) differ little from the average equity volatility of 0.492.

Graph A of Figure 1 compares actual leverage measures with LT model implied financial leverage. Actual leverage for net debt is always lower than actual leverage for total debt because of cash holdings. The changes in cash holdings are small compared to changes in total debt so that the series track each other closely. Actual leverage increased through the 1960s and early 1970s, but then started to trend downward until 2000. However, our LT implied leverage measure suggests that since the late 1960s implied leverage is much lower than either measure of actual leverage. LT implied leverage shows neither the big long-term run-up nor the substantial decline of actual leverage.

[Insert Figure 1 About Here]

Since our analysis of this type of structural model is novel, we also examine the potential for estimation bias. Our primary concern is that not explicitly accounting for measurement error of asset volatility or leverage separately could result in biased estimates of risk determinants or implied leverage (much like a traditional errors-in-variables problem). We investigate this possibility through a simulation analysis of unmodeled noise in asset volatility (i.e., in Equation 5) and in leverage (i.e., in Equation 7). The details of the analysis are provided in Appendix B, and we briefly summarize them here: The potential misspecification of asset volatility results in errors of indeterminate sign for the coefficient estimates but a consistent downward bias on implied leverage and a consistent upward bias in implied asset volatility. These effects are small, even when we assume extremely high levels of measurement error for asset volatility. However, measurement error for financial leverage can lead to larger biases. Consequently, we have also estimated $LeverageFactors$ and asset volatilities that adjust for a reasonably high level of measurement error in net debt levels. Graph A of Figure 1 also plots the LT implied leverage measures adjusted for potential bias.

The bias-adjusted LT implied leverage consistently plots above the unadjusted measure. The magnitude of the estimated bias increases during the 1970s and early 1980s resulting in an implied leverage measure that more closely follows the observed leverage trend. However, the magnitude of implied leverage adjusted for bias is still quite low compared to actual leverage. Consequently, we are confident concluding that implied leverage is consistently much lower than observed leverage even in the case that our estimation suffers from estimation biases. It is also interesting to note that despite by-year estimation of the models, our measures of implied leverage are more stable than actual leverage measures.

Graph B of Figure 1 plots equity volatility and our estimates of asset volatility from the LT model. Because implied leverage is relatively stable compared to asset volatility, the two series track each other closely. The plots show the well-documented upward trend in firm risk from 1964-2000. In fact, asset volatility shows an even stronger trend than equity volatility because leverage tends to decline over this period. This result holds for both implied and actual leverage measures. This finding is consistent with the conclusions of previous research that growth options, profit volatility, and other characteristics associate with firm assets, and economic risk explain the trend in idiosyncratic risk.[15] Overall, the average decline in leverage (both actual and implied) over the last three decades indicates that any upward trend in equity volatility was driven entirely by economic risk factors and declines in financial risk actually mitigated the severity of the change.

While our analysis with the LT model suggests that model misspecification and estimation bias are unlikely to drive our conclusions, it is impossible to know this with certainty. Consequently, we now turn to the time-series model evidence which provides an entirely independent assessment of the importance of financial risk.

C. *Time-Series Model Results*

We follow the methodology described in Choi and Richardson (2009) and define asset returns as unlevered equity returns, using net debt as the measure of leverage. We also restrict our sample to 1991-2008 initially.[16] Table 4 shows summary statistics of quarterly data over this period for our full sample of firms. We also divide our sample into 5 groups based on the average level of net debt. Low (< 0.10) net debt firms are the largest group making up 628 (29.2%) of the 2,151 firms in our sample.

[Insert Table 4 About Here]

[15] See, for example, Irvine and Pontiff (2009); Cao et al. (2008).

[16] This represents the period of primary interest, and also matches the Choi and Richardson (C&R) sample period thus facilitating comparisons to their results. We thank the authors for providing a list of firms in their sample. Of the 853 firms in the Choi and Richardson (2009) sample, 641 are present in our sample. The primary difference in sample construction comes from Choi and Richardson selecting their sample based on the availability of publicly available information on debt issues. We do not limit our sample to firms with detailed debt data. As Choi and Richardson note, their sample firms tend to have significantly higher leverage and larger size than the CRSP universe (as well as our sample) because the bond data base does not include small firms with small amounts of debt (p. 4).

Table 5 shows results of model estimation for equity volatility for the augmented EGARCH model for the five different leverage groups defined in Table 4. In addition to the firm characteristics of interest we also include the level of the Chicago Federal Reserve's National Activity Index (CFNAI) to account for well-known time-variation in volatility related to the business cycle. Inspection of the coefficients and marginal effects indicates that many of the firm characteristics are both statistically and economically important in the same ways as in the LT model estimation. For example, firm size and dividend yield have strong negative relations to equity volatility, whereas profit volatility has a strong positive relation. Total debt also has a large positive effect on equity volatility suggesting that financial leverage is an important factor for determining total risk.[17]

[Insert Table 5 About Here]

Implicit in our analysis is an assumption that firms will adjust financial policies based on the characteristics we have chosen for modeling asset volatility. As a consequence, we should expect that firms with different leverage profiles would have different risk sensitivities to the factors we examine. Overall, the EGARCH parameters in Table 5 are very stable across the groups. In contrast, firm characteristics have varying effects with some increasing and others decreasing in importance with higher debt levels. We still observe that for each of the groups several of the firm characteristics are important. For the asset characteristics, firm size, and profit volatility consistently have the greatest effects on equity volatility. Dividend yield also has a large and consistently negative relation with risk.

The most interesting result in these tests comes from observing the effects related to total debt. The effect of debt on total risk decreases monotonically as debt levels increase, and the decline is substantial both in absolute and relative terms. Specifically, total debt is by far the most important determinant of risk for the lowest leverage group with a marginal effect of 0.049, or 4.9% annualized standard deviation. For the highest leverage group, the marginal effect of total debt falls to 0.009 and is only the fourth most important determinant of total risk. The fact that the relative importance and marginal effects for total debt get smaller as leverage increases is consistent with firms with high debt levels undertaking more financial risk management. If the expected costs of financial distress increase with leverage (e.g., the probability of distress increases), this would be the expected strategy as long as there exist costs associated with running a risk management program. For example, previous research suggests that there are both significant fixed and variable costs of hedging with derivatives (see Brown (2001)). This does not mean that firms with low levels of leverage do not manage financial risk, just that these firms appear not to do so to the same

[17] In Table A.9 of the Appendix we report results for estimation using the full sample and both equity and asset volatility as the dependent variables. Model estimation for asset volatility reveals quite similar results for the asset characteristics. The coefficient on total debt is negative in the asset volatility model suggesting that firms with high asset volatility have lower debt. This result combined with the positive coefficients on cash holdings and debt maturity provide further support for the theory that firms with riskier operations will undertake more conservative financial policies in an attempt to manage the level of total risk.

degree as firms with higher leverage. Likewise, this finding is consistent with firms that have a very high sensitivity to debt choosing a very low exposure to financial risk. For the other financial risk factors (cash and debt maturity), the coefficients are only sometimes statistically significant, and the marginal effects are typically quite small.

Overall, the results of the augmented EGARCH analysis suggest that factors hypothesized to be associated with asset characteristics (e.g., size and profit volatility) and financial policy (e.g. total debt) are both important for determining equity volatility. In contrast to our analysis utilizing the Leland-Toft model, the consistently positive and statistically significant relation between total debt and risk suggest that financial risk is an economically important determinant of equity volatility. However, we find the biggest sensitivities for the firms with the least debt and during the recent period of relatively low debt levels. Consequently, it is not possible to determine from the previous analysis the relative importance of these effects. To gain insight into the overall importance of financial risk, we conduct a volatility decomposition (as in Choi and Richardson (2009)) to identify how much of total risk can be attributed to asset volatility and how much to financial leverage. The results are presented in Table 6.

[**Insert Table 6 About Here**]

The conclusions of this analysis are very similar to those obtained for the Leland-Toft model in so far as a large majority of equity volatility can be attributed to asset volatility. For the median (average) firm asset volatility accounts for 84.7% (67.6%) of equity volatility. These summary values conceal substantial variation across leverage groups. Despite the much higher sensitivities to total debt for low leverage firms (documented in Table 5), the vast majority of equity volatility is accounted for by asset volatility for the lowest leverage group. As leverage increases the importance of financial risk increases monotonically. For the two highest leverage groups, financial risk accounts for the majority of equity volatility. In fact, for the highest leverage firms, the importance of financial risk is quite pronounced. However, this group consists of just 15.2% of firms and 6.3% of total assets in our sample.

Overall, the analysis using time-series models is complementary to the analysis using the Leland-Toft model. In both cases, we were able to identify important firm characteristics that are significantly related to equity volatility. The most important of these appear to be firm size, profit volatility, and dividend policy. Other factors seem to be of secondary importance for the typical firm, though the level of debt appears to be the driving force of risk for a relatively small number of highly leverage firms. In general, it is worth noting that the methodology seems able to identify firms where financial risk is quite important, but these firms are the exception rather than the rule.

VI. Additional Tests

In this section we discuss results from alternative specifications and robustness tests.

A. Reality Check

Given the surprising nature of our results, it seems worthwhile to step back and see if our results are consistent with other broad trends in corporate finance. As already shown in Figure 1, actual debt levels (as well as our implied debt levels) have declined steadily since about 1980. One drawback to this analysis is that it does not consider the cash flows associated with financial leverage and in particular the interest expense associated with debt. If firms are becoming riskier, it may also be the case that interest expense has increased as firms must pay larger risk premiums to lenders. On the other hand, interest rates in most countries, including the U.S. have trended down since the early 1980s. Even if interest expense does not increase for a typical firm, lower and more volatile income (e.g., associated with the many new and younger public firms) could mean that effective debt burdens have increased. If firms are in fact reducing financial leverage to negligible levels, this should be reflected in cash flows associated with whatever policies are being used to reduce risks. In short, if financial risks are declining toward zero, the cash flow burden of leverage should be following a similar trend.

To investigate these issues, we calculate total interest expense as a percent of total operating income each year for our sample of firms. To smooth out cyclical variation in operating income we calculate a 5-year centered moving average. The dotted line in Figure 2 plots the result. The broad trends in this measure mimic the trends in actual leverage plotted in Figure 1. The relative burden of debt increases by a factor of three from 1964 to 1984 and then declines by about a half from 1990 to the end of the sample. Nonetheless, the ratio in 2009 is still at roughly the same level as in 1970 suggesting that leverage may continue to be a significant source of financial risk. A significant shortcoming of this ratio is that it does not account for other policies that could mitigate (or exacerbate) the risks of debt such as liquidity management, dividend policy, or risk management with derivatives. To adjust for the net effect of other financial policies on the cash flows of firms, we adjust interest expense by the change in cash holdings and again calculate the ratio to operating income. The solid line in Figure 2 plots this series. Surprisingly, large increases in cash holdings after 1990 offset interest expenses on debt so that by 2003 this ratio is zero. Since 2003 the ratio has increased, but remains below the lowest level measured prior to 2000.

[**Insert Figure 2 About Here**]

While this analysis cannot document the precise sources of these increased cash holdings, they are no doubt the result of deliberate policies which result in a reduction of financial risks. Most importantly, this analysis shows that our estimates of increasingly low implied financial risk levels are very consistent with the actual cash flow positions of nonfinancial firms.

B. Other Tests

Our analysis is that the market is able to look through accounting data and determine the actual level of financial risk that a firm is taking. One way to gauge the accuracy of this assumption is to compare explicit measures of financial distress based on accounting data versus measures that also utilize market data.[18] More specifically, the difference between accounting-based and market-based distress measures should be related to the difference between actual leverage and our implied leverage estimates. We utilize the Altman (1968) Z-Score as a more market-based measure of distress because it includes the market value of the firm as one of its components. We utilize the Ohlson (1980) O-Score as a purely accounting-based measure of distress since it only includes accounting-based components. Using a variety of methods, we compare the differences in ranks for these two measures to the differences in actual and implied leverage and find a consistently positive and statistically significant relation (detailed results are presented in the Appendix, Table A.10). This finding is consistent with the market being able to evaluate the true financial risk levels of firms beyond what is implied by just accounting data.

Section B of the Internet Appendix provides a detailed discussion of results from robustness tests that we briefly summarize here. First, we explore the determinants of firm risk over time. We find that the $LeverageFactor$ estimate from the LT model has declined from values near 0.6 in the early 1970s to around 0.1 in the late 1990s. This finding suggests that financial risk has had a dampening effect on the time trend in equity volatility when combined with declines in both total and net debt over the same time period. The decline in financial risk over this period is also consistent with the growing trend in financial risk management.

Next, we present results from a less-restrictive reduced-form model of firm risk that are similar to our main results. Financial risk, including leverage related to total debt, does not appear to have a substantial effect on equity volatility for the typical firm. Consequently, the form of the model we use does not seem to matter much for our conclusions.

Finally, we verify that our results are robust. Specifically, our LT model results hold for alternative specifications. We also verify that a potential misspecification in asset volatility does not seem to impact estimates for the lowest leverage group of firms in that market leverage is estimated to be insignificantly different from 1.0 (unleveled firms) in both the pooled and Fama-MacBeth estimations. Moreover, re-estimating the LT model for each leverage group results in implied leverage estimates that increase with actual leverage but at a slower rate consistent with higher leverage firms managing financial risk more. For example, estimates that include information on the use of financial derivatives suggest that this type of risk management explains about a quarter of the difference between actual and implied leverage.

VII. Conclusions

Financial policy can be viewed as transforming asset volatility into equity volatility through net financial leverage. In this paper, we study this relationship using data for the United States

[18]We thank an anonymous referee for making this suggestion.

between 1964 and 2009 in a unifying framework suggested by Leland and Toft (1996) and a time-series (EGARCH) model that includes firm characteristics. To the best of our knowledge, no empirical study has attempted to analyze the determinants of firm risk using structural and time-series models with a large number of choice variables.

The results of our analysis are surprising. Despite the sizable actual leverage ratio of about 1.5, implied leverage as estimated by our implementation of the Leland-Toft model is within the range of only 1.03 and 1.11. When we conduct an entirely independent variance decomposition based on the estimation of our augmented EGARCH model we find that asset volatility accounts for 84.7% of total volatility for the median firm. Thus using these two separate methods, we measure a relatively small wedge between asset and equity volatility for the typical firm. As would be expected, implied financial risk is higher for the relatively small number of firms with high leverage. However, even many of these firms appear to have significantly lower implied leverage than book leverage. In addition, implied leverage seems to be declining over the last three decades in contrast to the upward trend in asset volatility.

Results for firm characteristics are also interesting. We find that the variation in equity volatility is driven primarily by economic risk factors. Specifically, we find that larger firms with more mature lines of business, higher profitability, and lower profit volatility have significantly lower firm risk. Financial risk factors tend to have a smaller impact on firm risk in general. This pattern is consistent with the hypothesis that carefully implemented financial policy has helped U.S. firms to effectively manage financial risks.

In short, our results suggest that, as a practical matter, residual financial risk is now relatively unimportant for the typical U.S. firm. This finding raises questions about the level of expected financial distress costs since the probability of financial distress is likely to be lower than assumed for most companies. For example, our results suggest that estimates of the level of systematic risk in bond pricing may be biased if they do not take into account the trend in implied financial leverage (e.g., Dichev (1998)). Our results also bring into question the appropriateness of financial models used to estimate default probabilities, since financial policies that may be difficult to observe appear to significantly reduce risk. In essence, this relation makes the credit spread puzzle even more puzzling. Finally, our results imply that the fundamental risks born by shareholders are primarily related to underlying economic risks, which should lead to a relatively efficient allocation of capital in the corporate nonfinancial sector.

Some readers may be tempted to interpret our results as indicating that financial risk does not matter. This view is *not* the correct interpretation. Instead, our results suggest that firms choose (or manage) financial risk so that the resulting exposure to shareholders is usually low compared to economic risks. Of course, financial risk is important to firms that choose to take on such risks through high debt levels, high interest rate exposure, poor liquidity management, a lack of risk management, etc. However, our study suggests that the typical non-financial firm chooses not to take significant financial risks. This finding contrasts with fundamental economic and business risks that are more difficult (or undesirable) to hedge because they represent the mechanism by which the firm earns economic profits.

In summary, despite some fractured evidence in the literature, we have yet to understand the fundamental drivers of firm risk. As such, our results have important implications for many areas of finance. For example, our analysis informs the corporate finance literature in its attempt to identify relevant risk factors for firm valuation, investment and financing policies. Delineating between economic risk and financial risk and identifying the drivers of these risks provides a basis for effective risk management. Our results are also important for asset pricing models that attempt to identify and quantify prevalent properties of firm and market-wide risk.

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Table 1: Summary Statistics and Correlations of Variables

This table reports summary statistics and Pearson correlation coefficients among equity volatility, economic risk, and financial risk factors in columns, and various variables of interest in rows for the sample of annual data between 1964 and 2009. Equity volatility is annualized standard deviation of daily stock returns from CRSP. Total assets is a proxy for firm size. Age is the difference between the measurement year and the minimum of (i) year of listing data from Jovanovic and Rousseau (2001) and (ii) the firm's initial appearance on CRSP monthly database. Tangible Assets is gross PP&E divided by total assets. Capital expenditures is capital expenditures divided by total assets. Profitability is operating income before depreciation divided by sales. Profit volatility is the five-year central standard deviation of profitability. Dividend yield is common dividends divided by market capitalization (absolute value of closing price*shares outstanding from CRSP). Total debt/market capitalization is long-term debt plus current liabilities plus preferred stock divided by market capitalization. Cash/market capitalization is cash and short-term investments (STI) divided by market capitalization. Net debt/market capitalization is (total debt – cash & STI) divided by market capitalization. Total debt/total assets (BV) is total debt divided by the sum of total debt and equity book value. Debt maturity is long-term debt divided by total debt. Coupon rate is interest expense plus preferred dividends divided by total debt. All accounting data items are from CompuStat.

	Mean	Std. Dev.	Equity Vol	Total Assets (log)	Age (log)	Tang Assets	CapEx	Profit	Profit Vol	Div Yield	Total Debt / MktCap	Total Debt / TA (BV)	Cash / MktCap	Net Debt	Debt Maturity
Equity Volatility (annualized)	0.492	0.245													
Total Assets	290.3	1,664.0	-0.36												
Age	11.9	2.5	-0.39	0.49											
Tangible Assets	0.537	0.365	-0.24	0.22	0.24										
Capital Expenditures	0.073	0.069	-0.05	-0.01	-0.09	0.50									
Profitability	0.100	0.187	-0.41	0.32	0.16	0.28	0.20								
Profit Volatility	0.072	0.122	0.49	-0.33	-0.28	-0.16	0.00	-0.65							
Dividend Yield	0.013	0.019	-0.44	0.20	0.37	0.25	-0.02	0.16	-0.27						
Total Debt / Market Capitalization	0.717	1.009	0.03	0.17	0.09	0.12	-0.02	0.02	-0.15	0.16					
Total Debt / Total Assets (Book Value)	0.435	0.201	-0.08	0.31	0.14	0.16	0.06	0.07	-0.21	0.08	0.59				
Cash / Market Capitalization	0.138	0.156	0.22	-0.10	-0.08	-0.18	-0.16	-0.25	0.20	-0.04	0.21	-0.08			
Net Debt / Market Capitalization	0.579	0.989	-0.01	0.19	0.10	0.15	0.01	0.06	-0.19	0.17	0.99	0.61	0.05		
Debt Maturity	0.358	0.275	-0.15	0.28	0.11	0.35	0.19	0.18	-0.11	0.10	0.38	0.58	-0.11	0.41	
Coupon Rate	0.036	0.027	-0.05	0.13	0.09	0.28	0.11	0.08	-0.06	0.09	0.39	0.48	-0.12	0.41	0.62

Table 2: Means of Variables by Volatility Quartiles

The table reports the means of equity volatility, economic risk, and financial risk factors by volatility quartiles for the sample of annual observations between 1964 and 2009. Equity volatility is annualized standard deviation of daily stock returns from CRSP. Total assets is a proxy for firm size. Age is the difference between the measurement year and the minimum of (i) year of listing data from Jovanovic and Rousseau (2001) and (ii) the firm's initial appearance on CRSP monthly database. Tangible Assets is gross PP&E divided by total assets. Capital expenditures is capital expenditures divided by total assets. Profitability is operating income before depreciation divided by sales. Profit volatility is the five-year central standard deviation of profitability. Dividend yield is common dividends divided by market capitalization (absolute value of closing price*shares outstanding from CRSP). Total debt/market capitalization is long-term debt plus current liabilities plus preferred stock divided by market capitalization. Cash/market capitalization is cash and short-term investments (STI) divided by market capitalization. Net debt/market capitalization is (total debt – cash & STI) divided by market capitalization. Total debt/total assets (BV) is total debt divided by the sum of total debt and equity book value. Debt maturity is long-term debt divided by total debt. Coupon rate is interest expense plus preferred dividends divided by total debt. All accounting data items are from CompuStat.

	Equity Volatility Quartile			
	1st	2nd	3rd	4th
Equity Volatility (annualized)	0.247	0.374	0.517	0.831
Total Assets (MM)	773.6	373.5	205.4	119.7
Age (years)	28.1	19.5	14.0	10.1
Tangible Assets	0.653	0.577	0.499	0.420
Capital Expenditures	0.073	0.077	0.077	0.066
Profitability	0.160	0.143	0.109	-0.012
Profit Volatility	0.021	0.037	0.070	0.160
Dividend Yield	0.026	0.015	0.007	0.002
Total Debt / Market Capitalization	0.646	0.740	0.754	0.727
Total Debt / Total Assets (BV)	0.098	0.119	0.146	0.190
Cash / Market Capitalization	0.548	0.621	0.608	0.538
Net Debt / Market Capitalization	0.452	0.453	0.433	0.402
Debt Maturity	0.391	0.393	0.355	0.291
Coupon Rate	0.038	0.038	0.036	0.033

Table 3: Leland-Toft Model Estimation Results

The table shows Leland Toft (LT) model coefficient estimates, p-values, and marginal effects from pooled and Fama-MacBeth regressions for the sample between 1964 and 2009. The table also provides predicted values and standard deviations for σ_A (volatility of assets) and Implied Financial Leverage (l) as defined in Equations 5 and 2. Marginal effects are defined as the change in total risk resulting from a one-standard deviation increase (from the mean) in the independent variable, with other independent variables set to their mean values. Total assets is a proxy for firm size. Age is the difference between the measurement year and the minimum of (i) the year of listing data from Jovanovic and Rousseau (2001) and (ii) the firm's initial appearance in the CRSP monthly database. Tangible assets is gross PP&E divided by total assets. Capital expenditures is capital expenditures divided by total assets. Profitability is operating income before depreciation divided by sales. Profit volatility is the five-year central standard deviation of profitability. Dividend yield is common dividends divided by market capitalization (absolute value of closing price*shares outstanding from CRSP). $LeverageFactor$ is defined in Equation 7. All accounting data items are from CompuStat.

	Pooled Sample			Fama-MacBeth		
Parameter	Estimate	p-value	ME	Mean	p-value	ME
Intercept (β_0)	-0.21	<0.001		-0.27	<0.001	
Total Assets (log)	-0.04	<0.001	-0.069	-0.09	<0.001	-0.156
Age (log)	-0.07	<0.001	-0.064	-0.03	<0.001	-0.027
Tangible Assets	-0.02	<0.001	-0.007	0.01	0.628	0.004
Capital Expenditures	-0.32	<0.001	-0.022	-0.22	0.002	-0.015
Profitability	-0.27	<0.001	-0.049	-0.24	<0.001	-0.044
Profit Volatility	0.68	<0.001	0.081	0.86	<0.001	0.102
Dividend Yield	-10.48	<0.001	-0.199	-8.43	<0.001	-0.160
Leverage Factor	0.10	<0.001		0.28	<0.001	

Implied Values	Mean	Std. Dev.		Mean	Std. Dev.	
σ_A	0.475	0.160		0.396	0.175	
Implied Financial Leverage (l)	1.029	0.034		1.105	0.081	

Table 4: Time-Series Sample Statistics

This table reports summary statistics by leverage group for our full sample of firms. Breakpoints for leverage groups are based on our net debt measure and correspond to those reported in Choi and Richardson. We also restrict this sample period to the years 1991-2008 examined in Choi and Richardson (2009). Data are quarterly and the reported values are means across pooled observations. Total assets is a proxy for firm size. Age is the difference between the measurement year and the minimum of (i) the year of listing data from Jovanovic and Rousseau (2001) and (ii) the firm's initial appearance in the CRSP monthly database. Tangible Assets is gross PP&E divided by total assets. Capital expenditures is capital expenditures divided by total assets. Profitability is operating income before depreciation divided by sales. Profit volatility is the five-year central standard deviation of profitability. Dividend yield is common dividends divided by market capitalization (closing price*shares outstanding from CRSP). Total debt/market capitalization is long-term debt plus current liabilities plus preferred stock divided by market capitalization. Cash/market capitalization is cash and short-term investments (STI) divided by market capitalization. Net debt/market capitalization is (total debt – cash & STI) divided by market capitalization. Debt maturity is long-term debt divided by total debt. Likewise, profit volatility is capped at 50%. All accounting data items are from CompuStat.

	Full Sample	Net Debt < 0.10	$0.10 \leq$ Net Debt < 0.35	$0.35 \leq$ Net Debt < 0.62	$0.62 \leq$ Net Debt < 1.06	Net Debt ≥ 1.06
Number of Firms	2,151	628	503	383	310	327
Number of Firm-Qtrs	86,333	23,913	21,966	15,487	12,667	12,300
Total Assets (MM)	2,216	987	2,555	3,662	2,725	1,829
Age (years)	18.0	13.1	20.1	21.7	19.3	17.1
Tangible Assets	0.596	0.414	0.639	0.696	0.712	0.637
Capital Expenditures	0.065	0.055	0.072	0.075	0.071	0.059
Profitability	0.051	0.000	0.073	0.087	0.069	0.054
Profit Volatility	0.092	0.155	0.077	0.062	0.064	0.055
Dividend Yield	0.007	0.004	0.008	0.010	0.000	0.000
Total Debt / Market Cap	0.669	0.126	0.303	0.544	0.900	2.205
Cash / Market Cap	0.105	0.167	0.070	0.061	0.067	0.128
Net Debt / Market Cap	0.554	-0.042	0.223	0.468	0.817	2.058
Debt Maturity	0.646	0.885	0.651	0.529	0.496	0.450

Table 5: Equity Volatility Time-Series Model Estimates by Leverage Group

This table reports estimated coefficients, p-values and marginal effects for the augmented EGARCH model by leverage group. The model being estimated is defined in the main text in equations (3-4). We also restrict this sample period to the years 1991-2008 examined in Choi and Richardson. Marginal effects (ME) are changes in volatility for a one standard deviation change in the firm characteristic. Estimation is conducted using the pooled sample of quarterly returns. Firm Characteristics are defined in the header of Table 4. CFNAI is the Chicago Federal Reserve's National Activity Index.

	Net Debt < 0.10			$0.10 \leq$ Net Debt < 0.35			$0.35 \leq$ Net Debt < 0.62			$0.62 \leq$ Net Debt < 1.06			Net Debt ≥ 1.06		
	Est.	p-value	ME	Est.	p-value	ME	Est.	p-value	ME	Est.	p-value	ME	Est.	p-value	ME
EGARCH Parameters															
c	-0.077	<.001		-0.237	0.092		-0.389	<.001		-0.464	0.056		-0.168	<.001	
α	0.363	<.001		0.357	<.001		0.349	<.001		0.304	<.001		0.273	<.001	
β	0.858	<.001		0.831	<.001		0.823	<.001		0.804	<.001		0.872	<.001	
γ	-0.122	<.001		-0.110	<.001		-0.128	<.001		-0.106	<.001		-0.129	<.001	
Firm Characteristics															
Total Assets (log)	-0.040	<.001	-0.029	-0.044	<.001	-0.023	-0.034	<.001	-0.016	-0.035	<.001	-0.016	-0.029	<.001	-0.017
Age (log)	-0.023	<.001	-0.007	-0.003	0.442	-0.001	0.006	0.190	0.001	-0.010	0.032	-0.002	0.002	0.634	0.000
Tangible Assets	0.085	<.001	0.012	-0.005	0.625	-0.000	-0.022	0.054	-0.002	0.021	0.086	0.002	0.012	0.219	0.001
Capital Expenditures	-0.412	<.001	-0.008	0.027	0.655	0.000	-0.037	0.602	-0.001	-0.110	0.176	-0.001	-0.155	0.017	-0.003
Profitability	0.038	0.068	0.002	0.026	0.381	0.001	-0.012	0.767	-0.000	0.034	0.459	0.001	-0.224	<.001	-0.011
Profit Volatility	0.591	<.001	0.030	0.438	<.001	0.016	0.478	<.001	0.016	0.398	<.001	0.013	0.255	<.001	0.010
Dividend Yield	-4.315	<.001	-0.019	-4.238	<.001	-0.013	-3.334	<.001	-0.010	-3.615	<.001	-0.010	-2.045	<.001	-0.007
Total Debt/Market Cap	0.144	<.001	0.049	0.142	<.001	0.035	0.099	<.001	0.022	0.083	<.001	0.018	0.032	<.001	0.009
Cash/Market Cap	-0.130	<.001	-0.006	0.016	0.610	0.001	0.135	<.001	0.004	0.019	0.638	0.001	-0.023	0.193	-0.001
Debt Maturity	-0.018	0.195	-0.002	0.022	0.130	0.002	0.089	<.001	0.006	0.174	<.001	0.012	-0.015	0.344	-0.001
Macro Characteristics															
CFNAI	0.014	0.038	0.004	-0.062	<.001	-0.011	-0.075	<.001	-0.013	-0.098	<.001	-0.016	-0.076	<.001	-0.016
Number of Firms	628			503			383			310			327		

Table 6: Volatility Decomposition from Time-Series Model Estimates

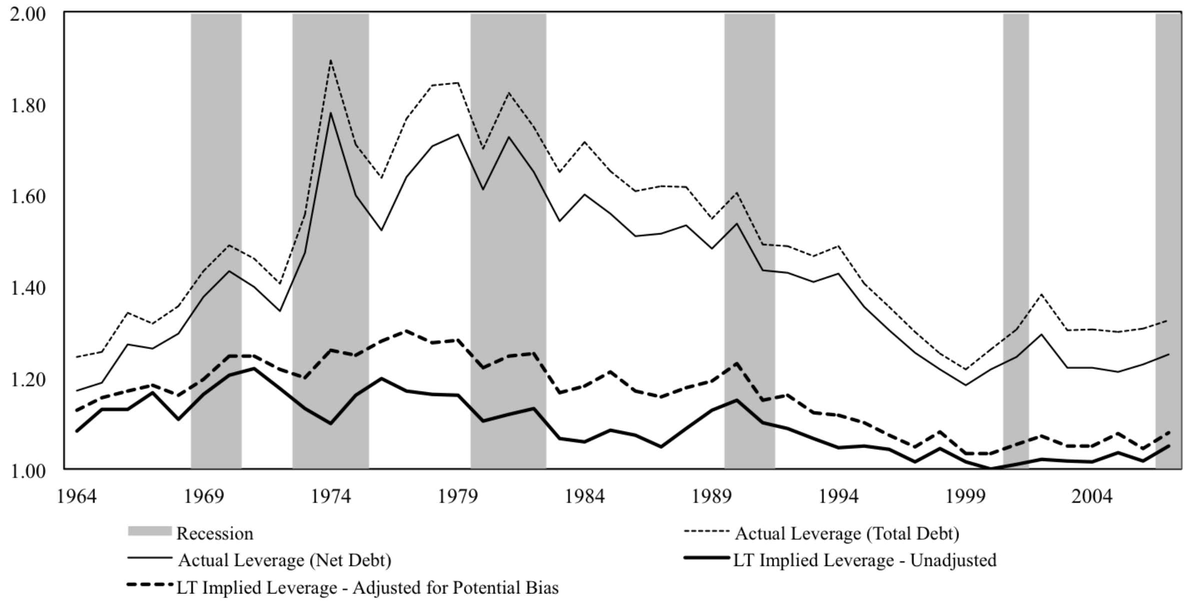
This table reports estimates of equity volatility contributions from asset volatility and financial risk (Asset/Equity) as described in Choi and Richardson (2009). We also restrict this sample period to the years 1991-2008. Mean and median values are reported for all firms and by leverage group. The model being estimated is defined in the main text in equations (3-4). Asset returns used to estimate the asset volatility model are derived from dividing equity returns by (1 + debt/equity). Estimation is conducted using the pooled sample of quarterly returns.

		Mean		Median	
	# of Firms	Asset/Equity	Asset Vol.	Asset/Equity	Asset Vol.
Net Debt < 0.10	628	7.3%	92.7%	1.6%	98.4%
$0.10 \leq$ Net Debt < 0.35	503	23.3%	76.7%	15.8%	84.2%
$0.35 \leq$ Net Debt < 0.62	383	40.5%	59.5%	34.7%	65.3%
$0.62 \leq$ Net Debt < 1.06	310	59.1%	40.9%	59.2%	40.8%
Net Debt ≥ 1.06	327	92.6%	7.4%	100.0%	0.0%
All Firms	2,151	32.4%	67.6%	15.3%	84.7%

Figure 1: Leverage Ratios and Volatility for Leland Toft Model

Graph A plots average values for implied leverage from the Leland-Toft model estimation presented in Table 3, actual leverage calculated using total debt, and actual leverage using net debt. Total debt and net debt are as defined in Table 1. We also plot LT measure adjusted for potential estimation bias as described in the Internet Appendix. Leverage is defined as 1.0 plus the relevant debt measure divided by the market value of equity. Graph B plots estimated levels of asset volatility from the LT model and equity volatility. Plotted values are annual estimates from 1964-2009. NBER-dated recessions are shaded in gray.

Graph A: Actual and Implied Leverage Ratios



Graph B: Equity and Asset Volatilities

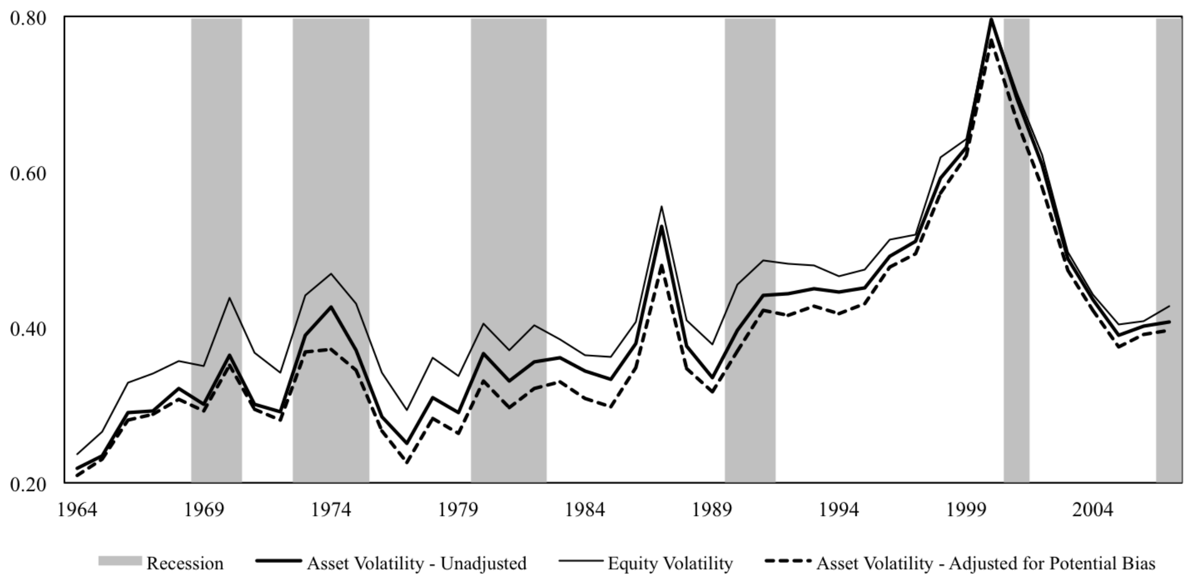
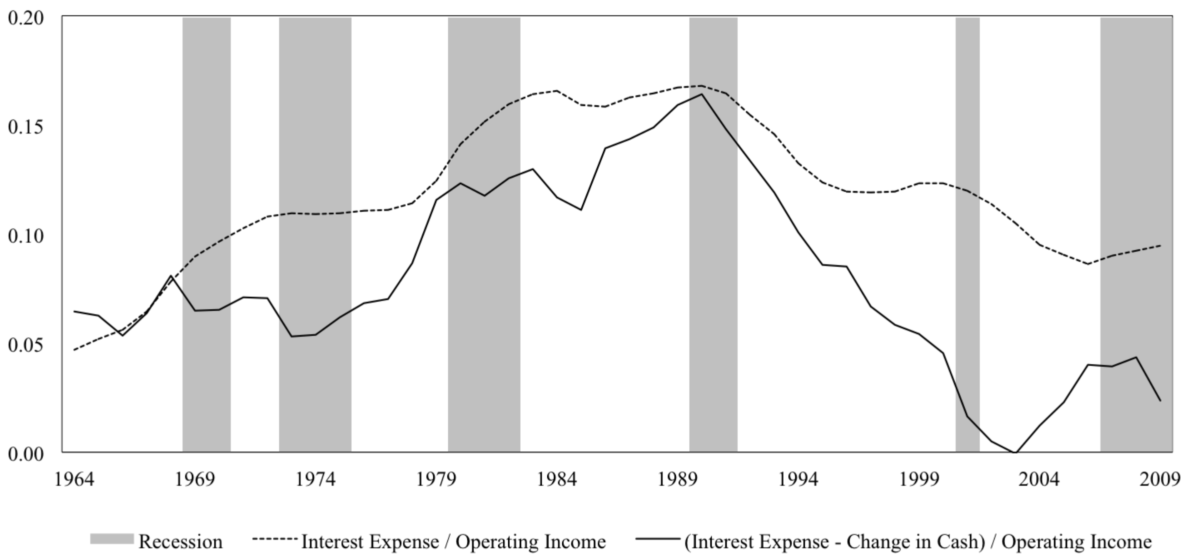


Figure 2: Aggregate Interest Expense

This figure plots centered 5-year moving averages of aggregate interest expense and aggregate interest expense less the aggregate change in cash and short-term investments scaled by operating income over the 1964-2009 sample period. The dotted line plots the sum of interest expense (CompuStat field XINT) across firms in our sample in a given year scaled by the sum of operating income (OIBDP). The solid line plots the sum of interest expense less the year-over-year change in cash and short-term investments (CHE) scaled by the sum of operating income. NBER-dated recessions are shaded in gray.



Internet Appendix for How Important is Financial Risk?

I. Leland-Toft Model

In this section we briefly review the main equations of the Leland-Toft model. We point readers to the original paper for a detailed discussion. The LT model builds on the trade-off theory of capital structure (i.e. corporate tax benefits versus bankruptcy costs and agency costs). Debt issues provide tax benefits that are balanced with higher probabilities of default. Equity holders aim to achieve the lowest bankruptcy trigger (equity value is maximized at the expense of the debt holders). This is the well-known asset substitution problem where around the optimal bankruptcy trigger, equity holders would want to take on riskier projects. Following Merton (1974), asset value (unleveraged value) follows a diffusion process

$$\text{(A.1)} \quad \frac{dV}{V} = [\mu(V,t) - \delta]\,dt + \sigma\,dz$$

where $\mu(V,t)$ is the total expected rate of return on value V, δ is the payout rate, and σ is the constant proportional volatility.

Consider a single bond that pays a continuous coupon, $c(t)$, with principal, $p(t)$, where t is the maturity. Upon bankruptcy, debt holders receive ρ fraction of firm value at bankruptcy VB. The value of this bond is given as:

$$\text{(A.2)} \quad \begin{aligned} d(V;V_B,t) = &\int_0^t e^{-rs}c(t)[1-F(s;V,VB)]ds + e^{-rt}p(t)[1-F(t;V,VB)] \\ &+ \int_0^t e^{-rs}\rho(t)VBf(s;V,VB)ds \end{aligned}$$

where $F(s;V,VB)$ and $f(s;V,VB)$ are the cumulative and incremental default probabilities. Integration by part gives:

$$\text{(A.3)} \quad \begin{aligned} &d(V;VB,t) = \frac{c(t)}{r} + e^{-rt}[p(t) - \frac{c(t)}{r}][1-F(t)] + [\rho(t)VB - \frac{c(t)}{r}]G(t), \\ &F(t) = N(h_1(t)) + (\frac{V}{VB})^{-2a}N(h_2(t)),\ G(t) = (\frac{v}{VB})^{-a+z}N(q_1(t)) + (\frac{V}{VB})^{-a-z}N(q_2(t)), \\ &q_1(t) = (\frac{-b - zt\sigma_A^2}{\sigma_A\sqrt{t}}),\ q_2(t) = (\frac{-b + zt\sigma_A^2}{\sigma_A\sqrt{t}}),\ h_1(t) = (\frac{-b - at\sigma_A^2}{\sigma_A\sqrt{t}}),\ h_2(t) = (\frac{-b + at\sigma_A^2}{\sigma_A\sqrt{t}}), \\ &a = \frac{r - \delta - 0.5\sigma_A^2}{\sigma_A^2},\ b = \log(\frac{V}{VB}),\ z = \frac{\sqrt{(a\sigma_A^2)^2 + 2r\sigma_A^2}}{\sigma_A^2},\ x = a + z. \end{aligned}$$

$N(\cdot)$ denotes the cumulative normal distribution.

Assuming that the firm continuously issues a constant principal amount of new debt with maturity T and simultaneously retires the same amount of debt[1], then the debt structure becomes independent of t, and the value of all outstanding bonds $D(V;VB,T)$ can be determined by integrating the debt flow, $d(V;VB,t)$, over a period of T:

(A.4)

$$D(V;VB,T) = \int_{t=0}^{T} d(V;VB,t)dt = \frac{C}{r} + (P - \frac{C}{r})(\frac{1-e^{-rT}}{rT} - I(T)) + ((1-\alpha)VB - \frac{C}{r})J(T),$$

$$I(T) = \frac{G(T) - F(T)e^{-rT}}{rT}, \; J(T) = \frac{-(\frac{V}{VB})^{-a+z}N(q_1(T))q_1(T) + (\frac{V}{VB})^{-a-z}N(q_2(T))q_2(T)}{z\sigma_A\sqrt{T}}.$$

The face value of debt is given by P.

In the LT model, v can be expressed in closed form as

(A.5) $$v(V;VB;T) = V + \frac{\tau C}{r}[1 - (\frac{V}{VB})^{-x}] - \alpha VB(\frac{V}{VB})^{-x}$$

where r is the risk-free rate, τ is the corporate tax rate, x is defined in Appendix A (as a function of δ, σ_A, and r). Intuitively, the market value of equity is equal to firm value minus debt value, where firm value is determined by adding the net of tax benefits and bankruptcy costs to the asset value V (i.e., unlevered firm value). Note that all of these value functions depend on V, VB, and T.

Equity value is then given by:

(A.6) $$E(V;VB;T) = v(V;VB;T) - D(V;VB;T).$$

The optimal bankruptcy trigger, VB, is found by using the smooth pasting condition:

(A.7) $$\frac{\partial E(V;VB;T)}{\partial V}\Big|_{V=VB} = 0.$$

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[1]Consequently, T can be considered the average maturity of debt for a given firm.

The smooth pasting condition gives the following bankruptcy trigger:

$$VB = \frac{(C/r)(A/(rT) - B) - AP/(rT) - \tau Cx/r)}{(1 + \alpha x - (1 - \alpha)B)},$$

$$\begin{aligned} A =& 2ae^{-rT} N(a\sigma_A\sqrt{T}) - 2zN(z\sigma_A\sqrt{T}) - \frac{2}{\sigma_A\sqrt{T}} n(z\sigma_A\sqrt{T}) \\ &+ \frac{2}{\sigma_A\sqrt{T}} e^{-rT} n(a\sigma_A\sqrt{T}) + (z - a), \end{aligned} \tag{A.8}$$

$$B = -(2z + \frac{2}{z\sigma_A^2 T}) N(z\sigma_A\sqrt{T}) - \frac{2}{\sigma_A\sqrt{T}} n(z\sigma_A\sqrt{T}) + (z - a) + \frac{1}{z\sigma_A^2 T}.$$

II. Sample Construction and Additional Tests

This section provides details of the sample construction, results from time-series variation in our estimated parameters, alternative specifications, and robustness tests.

A. Sample and Variable Construction

In the construction of our sample, we exclude 'micro-cap' companies (less than \$50 million in market capitalization from CRSP[2] or \$1 million in total assets measured in 2009 dollars) and 'penny stocks' with average share price less than \$1.00. We also exclude companies in the year of their initial public offering (IPO) and the year of their delisting. Firms with some missing or exceptional accounting data are also excluded. For example, we require the ratio of cash and short-term investments to market capitalization to be between zero and one, the ratio of debt to market capitalization to be nonnegative and less than ten, and the book value of equity to be positive. We also only consider firms with estimated annualized daily equity volatility (standard deviation of returns) between 1% and 200%. In effect, these screens eliminate firms that are on the verge of bankruptcy or unlikely to be a going concern. Thus, our conclusion that financial risks are relatively unimportant for a typical firm should not be interpreted as a statement that such risks are unimportant for *all* firms–obviously financial risks for firms on the verge of default are of great importance.

[Insert Table A.1 About Here]

Table A.1 shows the impact of constraints on our sample size. The first row (Full Sample) shows the number of firm-years for which the firm has sufficient return data in CRSP to calculate equity volatility and the firm appears in CompuStat. The next set of rows shows the importance of

[2]Market Capitalization is defined as the average over the firm-year of the product of the daily closing price per share as reported in CRSP and the number of shares outstanding.

independent screens on our sample size. The three most prevalent causes of lost firm-years are low market capitalization (27.0% of firm-years), listing or delisting (10.0% of firm-years), and missing variables of interest in CompuStat (5.7% of firm-years). All other constraints result in losing fewer than 5% of firm-years. Our final sample has 66,222 total firm-year observations. This results in an average of approximately 1,400 non-financial firms per year though the sample size tends to grow over time (at about the same rate as the total number of U.S. equity listings). In the time-series model estimation, we utilize quarterly data that is available for at least one quarter in each of the firm years in the annual sample.

We use total assets (CompuStat field AT) in 2009 dollars as a proxy for firm size. Firm age is based on the minimum of (i) the year of listing data from Jovanovic and Rousseau (2001) and (ii) the firm's initial appearance in the CRSP monthly database.[3] Our measure of profitability is operating income before depreciation (OIADP) divided by total revenue (REVT). We calculate profit volatility as the centered five-year standard deviation of our profitability measure.[4] Asset tangibility is calculated as gross property, plant, and equipment (PPEGT) divided by total assets. We normalize capital expenditures (CAPX) by total assets. Dividend yield is calculated as dividends on common stock (CDVC) divided by market capitalization (from CRSP).

We define total debt as the sum of current liabilities (LCT), long-term debt (DLTT), and preferred stock.[5] Debt maturity is defined as long-term debt plus preferred stock divided by total debt. As our measure of liquid assets we use holdings of cash and short-term investments (CHE) divided by market capitalization. In addition to these variables, we also report net debt (total debt - liquid assets) and the coupon rate, which is defined as the sum of interest expense (XINT) and preferred dividends (DVP) divided by total debt (including preferred stock). If firms have no debt we set the coupon rate to zero. In order to achieve convergence of the subsequent model estimation, we truncate some variables. Specifically, we cap the coupon rate at 11% and the dividend yield at 7.5%. Upper and lower bounds of +/-50% are applied to profitability because this variable has a small number of very extreme values. Likewise, profit volatility is capped at 50%. We also winsorize

[3] Data source: http://www.econ.nyu.edu/user/jovanovi/

[4] Except for 2008 and 2009 when we use the volatility of profits from 2005 to 2009.

[5] We have also conducted our analysis using debt in current liabilities instead of total current liabilities. However, since many companies use trade credit as a significant source of funding, we feel that using current liabilities provides a more realistic measure of economic debt and is a more conservative assumption. Regardless, our conclusions are unchanged if we use only the debt component of current liabilities for our calculation of total debt. For the value of preferred stock we use redemption value (PSTKRV), unless it is unavailable in which case we use liquidating value (PSTKL), unless it is unavailable in which case we use carrying value (UPSTK). While it makes little difference to our results, including preferred stock in total debt is a conservative assumption for our analysis, because it inflates financial leverage from the perspective of common equity holders. Thus, including preferred stock provides a measure that corresponds more closely with the role of debt in the LT model.

other variables at 1% and 99% to reduce the effect of outliers and possible data errors.[6]

B. Other Tests

1. Panel Regressions

We also conduct a simple test to examine the relative importance of different firm characteristics for total firm risk. Table A.2 reports estimates obtained from estimating panel regressions with annual observations of firm volatility as the dependent variable and firm characteristics as the independent variables. Results in the first column show that all firm characteristics except tangible assets are significantly related to firm volatility. For the asset characteristics, higher equity volatility is associated with smaller, younger firms that have lower CapEx and profits as well as higher profit volatility. For the financial characteristics, higher volatility is associated with more debt and shorter maturity debt as expected. However, as suggested by the correlations in Table 1, firms with high dividends and low cash holdings have lower, not higher, equity volatility. The adjusted R^2 for this regression is 0.427 which indicates that these 10 factors explain a large part of the overall variation in equity volatility.

[Insert Table A.2 About Here]

As a rough gauge of the relative importance of asset and financial characteristics, we estimate separate panel regressions for each set of risk factors. The results are reported in the remaining columns of Table A.2. We report results with and without dividend yield since the negative relation described above suggests it may be a measure of asset risk rather than financial risk. With the exception of tangible assets and CapEx, the statistical significance of the results are consistent across specifications. What differs is the amount of explanatory power. In particular, the large adjusted R^2 of the regressions with only the asset characteristics (including or not including dividends) demonstrates that these factors are responsible for most of the explanatory power of the full regression. In contrast, the low adjusted R^2 of 0.066 for the regression with just the "pure" financial characteristics (total debt, debt maturity, and cash) means that these factors probably account for only a small fraction of the explained variation.[7] This finding dovetails with our main results; however, this simple method does not account for the endogeneous nature of financial policy, the time-series properties of risk, or errors-in-variables problems associated with excluding significant explanatory variables for the regressions.

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[6] This winzorizing is necessary to increase the number of years that the estimation of the LT model converges. If this affects our results, the bias should work against our conclusions as discussed subsequently.

[7] We have also estimated these regressions with industry and year fixed effects. The results for the firm-characteristics are very similar and the adjusted R^2s of the each regression are increased by roughly 0.2. Thus, the implications for the analysis are essentially the same.

2. Correcting for Potential Estimation Bias

As noted in the main text, we investigate the potential for estimation bias in the LT model. A potential problem in our estimation arises if measurement error of asset volatility or leverage results in biased coefficient estimates of risk factors or our calculated levels of implied leverage. As a way of examining and correcting for this potential problem we conduct a series of simulations experiments to estimate the magnitude of any potential bias. After estimating the magnitude of the bias we are able to construct an adjusted time series of implied leverage that corrects for a reasonable level of measurement error.

We examine the possibility of measurement error separately for asset volatility and leverage. Because of the non-linear nature of the LT model, these sources of error can (and will) have different effects on our coefficient estimates, asset volatility estimates, and measure of implied leverage. The simulation analysis is designed as follows:

1. We generate a simulated dataset of all firm characteristics used as independent variables in our estimation. We match the number of observations, distributional properties, and correlations so that they are equivalent to those in the actual dataset.
2. Using these data and in-sample estimates of regression coefficients we then use our empirical specification of the LT model to generate estimates of asset volatility, implied leverage, and total volatility under the null of the $LeverageFactor$ equal to 1.0.
3. Using these data we estimate the LT model after adding unmodeled noise in asset volatility (i.e., in Equation 5) or in leverage (i.e., in Equation 7), or both. We vary the level of noise in each equation so that it is equivalent to 0%, 1%, 10%, 33%, 66%, or 100% of the standard deviation of estimated asset volatility or observed leverage (e.g., net debt / market capitalization).
4. We estimate the bias associated with different levels of measurement error by comparing the estimated coefficients from the estimations with noise to those from the estimations without noise.

We do this simulation exercise for both the pooled estimation and the Fama-MacBeth specification. The results of the analysis indicate that the potential misspecification of asset volatility results in small errors of indeterminate sign for the coefficient estimates but a consistent downward bias on implied leverage and a consistent upward bias in implied asset volatility. These effects are small, even when we add high levels of noise to the simulated data for asset volatility (e.g., 100% of the standard deviation of estimated asset volatility). For example, when we add this high level of noise in the pooled regression, the implied leverage value drops from its simulated "true value" of 1.558 to an estimated value of 1.493 and implied asset volatility increases from its simulated "true value" of 0.460 to 0.476. Furthermore all of the estimated coefficients on the firm characteristics are of the same sign, significance level and approximate magnitude as under the null hypothesis of no measurement error. Consequently, it is very unlikely that measurement error has a significant effect on our conclusions regarding the determinants asset volatility.

However, our simulation results show that measurement error for financial leverage can lead to more substantial biases. In particular, the effect on estimates of the $LeverageFactor$ can be substantial. Fortunately, the effects on risk factor coefficients remain small. When we add noise to the leverage equation with a standard deviation equal to that of net debt, the implied leverage value drops from its simulated "true value" of 1.558 to an estimated value of 1.302 and implied asset volatility increases from its simulated "true value" of 0.460 to 0.586. While it is very unlikely that actual measurement error of leverage would be this extreme, we consider this as providing an estimate of an upper bound to the bias. In our reported results, we calculate $LeverageFactors$ and asset volatilities that adjust for a more reasonable case of measurement error equivalent to 33% of the standard deviation of net debt. We do this for each annual estimate of the $LeverageFactor$ and denote these estimates as "Adjusted for Potential Bias". Graph A of Figure 1 compares actual leverage with both adjusted and unadjusted estimates of LT model implied financial leverage. Graph B of Figure 1 compares adjusted and unadjusted measures of asset volatility to observed equity volatility.

3. Determinants of Firm Risk over Time

Given increases in equity price risk documented by some prior research, it is interesting to attempt a decomposition of this trend into economic risk and financial risk components. In particular, a trend in the sensitivity of equity volatility to a certain firm characteristic or a trend in the characteristic itself could explain the trend in equity volatility. To examine this issue, we examine the coefficients from the annual cross-sectional regressions in the Fama-MacBeth estimation of the LT model. Figure A.1 plots the estimated coefficients (with 95% confidence intervals) with years that contained any part of a NBER-dated recession shaded. In almost every year, larger firms have lower risk though the relation seems to weaken periodically (e.g., during the early 1980s and late 1990s). The relation also appears to weaken (coefficients move toward zero) at the beginning of each recession though the effect is not substantial. Still, there is no apparent long-run trend in the relation between firm size and risk. Firm age becomes a significant driver of firm risk starting only in the early 1980s. In fact, in some years prior to 1982 firm age was significantly positively related to risk. The trend since the early 1980s is in line with findings documented by Brown and Kapadia (2007) that easier access to financial markets for riskier firms explains the trend in idiosyncratic risk and that the disappearance of many risky firms after the bursting of the tech bubble accounts for the decline after 2000. The relation appears to intensify during the last three recessions, suggesting that new firms experience greater changes in risk during economic downturns.

[Insert Figure A.1 About Here]

The results in Table 3 indicate that asset tangibility is not strongly related to risk over the whole sample period, but Figure A.1 shows that between 1995 and 2002 (the "dot-com" era) there was a significant negative relation. For capital expenditures, there is no apparent trend. The effect of profitability shows no trend, but the negative relation appears more stable during the 1980s and 1990s. Profit volatility has a consistently positive effect on firm risk. The effect appears to decline somewhat through the early 1980s and then holds relatively steady. In contrast, the significant negative relation between dividend yield and equity volatility is strong until just recently. None of these factors exhibit reliable correlations with the business cycle. All together among the economic risk characteristics, only firm age appears to exhibit a trend consistent with the observed trend in idiosyncratic risk. Thus if other factors are related to trends in risk, it is likely that the effect comes from time trends in the variables themselves versus a time-varying relation to idiosyncratic risk.

[Insert Table A.3 About Here]

The most dramatic trend between risk factors and equity volatility is observed for the $LeverageFactor$. Surprisingly, this factor did not increase as firms became riskier in the 1980s and 1990s, but instead declined steadily from values near 0.6 in the early 1970s to around 0.1 in the late 1990s. This finding, combined with the long steady decline in both total and net debt over the same time period,[8] suggests that financial risk has had a dampening effect on the time trend in equity volatility.

The augmented EGARCH model can also be utilized to examine trends in the importance of firm characteristics. We examine these trends by estimating the model for five different subperiods (1964-1973, 1974-1981, 1982-1990, 1991-2000, 2001-2009) including years before the Choi and Richardson (2009) sample period as well as 2009. The results are reported in Table A.3. As before, the EGARCH parameters are consistently significant and fairly stable. Only the α parameter appears to have changed substantially in the most recent two subperiods. The higher value for α indicates that the asymmetric response of volatility changes to positive and negative returns has increased in the last 20 years. As seen already, firm size, profit volatility, dividend policy, and total debt show the largest and most consistent relations to firm risk. All of the other factors are either not reliably significant or the signs of the coefficients change across subperiods. Interestingly, there is no apparent trend in the sensitivity to total debt, but the largest coefficient (0.096) is obtained for the most recent subperiod from 2001-2009. This coefficient may be capturing a higher level of financial risk exposure related to total debt during the 2008-2009 financial crisis.

4. Reduced-Form Model

One concern about the Leland-Toft model is that it does not provide a realistic characterization of corporate debt policy (Eom, Helwege, and Huang, 2004). The relatively rigid structural form of risk, and especially financial risk, could result in substantial model misspecification and misleading conclusions. For example, the only estimated variable in our specification of financial risk is the

[8]For example, see Bates, Kahle, and Stulz (2009) on increasing cash holdings of U.S. firms.

$LeverageFactor$. Consequently, the LT model may put too much structure on financial risk which leads to the low estimates of market leverage we obtain in the previous section. As a robustness test, we specify an alternative nonlinear model of equity price risk based on the same intuition that financial policy transforms asset volatility into equity price volatility through net financial leverage. This 'reduced-form' model (henceforth, the RF model) serves as a check on the LT method by allowing for any number of estimated financial risk factors and a less rigid structure. The model also serves as a robustness test for the augmented EGARCH model because it allows for direct estimation of the effects of various financial variables on total risk.

As before, we define equity price risk as the product of asset volatility and a leverage function so that

$$\text{(A.9)} \quad \sigma_E = \sigma_A(\mathbf{X})\, l(\mathbf{Y}, \sigma_A(\mathbf{X}))$$

where asset volatility (σ_A) is a function of operating characteristics of the firm ($\mathbf{X}$), and financial leverage (l) is a function of financial characteristics, $\mathbf{Y}$, as well as σ_A. Specifying a linear form for asset volatility results in

$$\text{(A.10)} \quad \sigma_E = \mathbf{X}'\beta\, (\mathbf{Y}'\Gamma(\mathbf{X}'\beta)),$$

where β and Γ are vectors of factor loadings for operating (economic) and financial factors, respectively.

Much like the LT model we define the volatility of assets as

$$\text{(A.11)} \quad \begin{aligned} \sigma_A = \mathbf{X}'\beta = & \beta_0 + \beta_1 Size + \beta_2 Age + \beta_3 TangibleAssets + \beta_4 Capex \\ & + \beta_5 Profitability + \beta_6 ProfitVolatility + \beta_7 DividendYield \end{aligned}$$

and, we define market leverage as

$$\text{(A.12)} \quad \begin{aligned} l = \mathbf{Y}'\Gamma(\mathbf{X}'\beta) = 1 & + \beta_8 TotalDebt/MarketCapital + \beta_9 TotalDebt/MarketCapital * \sigma_A \\ & + \beta_{10} DebtMaturity + \beta_{11} DebtMaturity * \sigma_A \\ & + \beta_{12} Cash/MarketCapital + \beta_{13} Cash/MarketCapital * \sigma_A \\ & + \beta_{14} DividendYield \end{aligned}$$

We then solve the nonlinear optimization problem by minimizing the squared deviations of predicted equity volatility from actual volatility subject to the constraint that $\beta_{14} \geq 0$.

Table A.4 reports the results for pooled and Fama-MacBeth regressions for our RF model. For the pooled estimation, all economic risk factors for σ_A are statistically significant at the 1% level and of the same sign as in the LT model. The RF model also seems able to account for endogeneity of financial policy in general. For financial risk factors, we find that total debt has a positive coefficient (as in the augmented EGARCH model). The positive coefficient on the interaction term between total debt and asset volatility suggests that equity volatility for firms with high debt and high asset volatility is higher than would be expected from just the linear relation with total debt. Cash remains positively related to equity volatility, whereas the interaction term for cash is negative. Debt maturity is negatively related to equity volatility. As evidenced by the negative interaction term, the reduction in equity volatility with longer debt maturity is stronger for firms with more economic risk. Dividends do not enter into the financial leverage term. For the Fama-MacBeth estimation, all the coefficients significant at the 5% level have the same sign as in the pooled regression though the magnitudes of coefficients differ somewhat. Results for tangible assets and capital expenditures are not significant. Except for total debt, none of the financial risk determinants are significant determinants of equity volatility in the Fama-MacBeth specification. Overall, these findings are largely consistent with the results for both the LT model and the augmented EGARCH model.

[Insert Table A.4 About Here]

The results for implied asset volatility and leverage are also quite similar to the results from the LT and EGARCH models. Specifically, implied asset volatility (σ_A) is similar to observed equity volatility, and implied leverage (financial risk) is low. The values of 1.047 for the pooled estimation and 1.085 for the Fama-MacBeth estimation are within one standard deviation of the LT estimates. This pattern again suggests that there is only a small wedge between asset volatility and equity volatility for the typical firm.

Time-series plots of coefficients from the Fama-MacBeth estimation of the RF model (not reported) further indicate that dynamic financial policy may have helped U.S. firms to better manage financial risks. While the interaction terms are not consistently significant, they show that the sensitivity of equity volatility to leverage appears to be decreasing with asset volatility until the early 1970s and then increasing starting in the late 1980s. The sensitivity of firm risk to cash holdings is decreasing in asset volatility after the late 1990s, whereas the positive impact of debt maturity on firm risk is declining with asset volatility. These results imply that managers try to find ways to alleviate financial risks.

Another advantage of the RF model is that we can further expand the specification to see if other factors are important determinants of risk. One specific concern is that our economic risk factors may be proxies for unobserved financial risk factors. This issue may cause underestimating the degree of financial risk since it is, in effect, swept into the specification of asset volatility. To test this hypothesis we include all of the economic risk factors in the specification for financial leverage (Equation A.12) and re-estimate the model. In the pooled regression (results not tabled), we find that each of the economic risk factors is an important determinant of leverage beyond the effect that each has on asset volatility. In the Fama-MacBeth analysis (also not reported), not all the factors are significant. Overall, the effects of these factors on financial risk are about an order of magnitude smaller than their effects on economic risk. Consequently, the mean square error declines by only about 7% with the addition of these 7 variables. Just as importantly, it is unlikely that these variables serve as proxies for factors associated with higher financial risk, because including them reduces the measure of implied market leverage. The reduced-form model also allows conducting the estimation with industry dummy variables as well as dummy variables for each year in the pooled estimation (When including these dummy variables in the LT model, the estimation algorithm does not converge because there are too many parameters to estimate.) Including these dummy variables leads to very similar results (not reported) for both coefficient estimates and implied leverage measures.

Altogether, results from the much less restrictive RF model are very similar to those from the structural LT model. Financial risk, including leverage related to total debt, does not appear to have a substantial effect on equity volatility for the typical firm. Consequently, the form of the model we use does not seem to matter much for our conclusions.

5. Other Robustness Tests

In some cases there are other proxies for the firm characteristics we want to examine. In particular, the market-to-book ratio is commonly used as a proxy for growth opportunities. In Table A.5 we report results from including the market-to-book ratio in place of capital expenditures in our LT estimation. The results suggest that M/B is negatively related to asset volatility. Given the abundance of results suggesting a positive relation between M/B and equity volatility (e.g., Cao et al. (2008)) we further investigate this relation and find that the result is driven by other firm characteristics considered in our analysis that cause a serious multi-colinearity problem. When we instead estimate the LT model with just M/B and no other firm characteristics, we find that there is a positive and significant relation with equity volatility for both the pooled estimation and the Fama-MacBeth estimation. When we estimate the time series model (Table A.6) with market-to-book we find the expected significant and positive relationships for both equity and asset volatilities.

[Insert Table A.5 and A.6 About Here]

Since we relate our results to the literature on idiosyncratic risk, we also repeat our time-series analysis using idiosyncratic risk as the dependent variable (e.g. the squared residuals from a Fama-French 3-factor model). Table A.7 reports these results. Comparing these results to those reported in the main text for total risk reveals coefficients of similar sign but with somewhat lower statistical significance and smaller marginal effects. These differences likely are caused by the fact that market risk makes up a large portion of total risk, thus the marginal effects will be smaller if there is any market-related component to asset volatility.

[Insert Table A.7 About Here]

To determine the effect of some of our assumptions on the parameter estimates we also conduct additional robustness tests. We do not table the results of these tests, but they are available upon request from the authors. First, we consider alternative specifications for the LT model that allow for a $LeverageFactor$ and separate intercepts for asset volatility and net debt (i.e., adding a constant to equations 5 and 7). In the Fama-MacBeth estimation the constant associated with financial leverage is not significant. In the pooled estimation, the value is significantly negative, which further reduces the estimate of implied leverage. If we specify the model with only a constant term in the financial leverage equation, the estimated value is still negative and again implies lower values for financial leverage.

Another way to gauge the relative importance of asset volatility misspecification is to exploit the fact that a large number of firms in the sample have essentially no debt. In particular, we estimate the LT model for just the lowest leverage group of firms (as reported in Table 6) with the constraint that the $LeverageFactor$ is equal to 1.0. Implied values for market leverage that were much different than 1.0 (or values for implied asset volatility that were much different from equity volatility) would indicate a possible problem. In fact, market leverage is estimated to be insignificantly different from 1.0 in both the pooled and Fama-MacBeth estimations.

As yet another test on the ability of the LT model to accurately estimate implied leverage and asset volatility, we estimate the model for each of the leverage groups in Table 3 without any constraint on the $LeverageFactor$. We would expect that implied leverage would increase with actual leverage (unless the estimated $LeverageFactor$ declines more rapidly than actual leverage increases). In fact, we find that as actual leverage increases, so does implied leverage. But, implied leverage increases more slowly than actual leverage suggesting that firms with higher leverage reduce financial risk more. This pattern may be because these firms are most sensitive to financial risk and coincides with the results for the augmented EGARCH model in Table 5.

So far, our results consistently indicate that financial risk is not only low for most firms, but lower than would be suggested by observed levels of debt. We hypothesize that firms undertake various types of financial policies under management's control to mitigate the increased equity volatility associated with higher debt. As noted these policies might include dynamically adjusting financing policies or even risk management with financial derivatives. Unfortunately, data on the use of financial derivatives is relatively hard to obtain. The best data at our disposal are available only for a subset of our firms in the 2000 to 2001 period (see Bartram, Brown, and Fehle (2009)) and consists of binary variables describing the use by firms of various types of derivatives (i.e., foreign exchange, interest rate, and commodity price derivatives).

We first incorporate the information on derivative use by including the binary variable for interest rate derivative use into the specification for financial policy. Specifically, we estimate a modified version of the LT model just for the years 1998 to 2003 where derivative use can affect the overall degree of financial leverage (by inserting a term into the leverage function). We find that the use of interest rate derivatives has a statistically significant negative effect on the degree of financial leverage, but the economic significance is modest. The estimated coefficient of -0.09 explains about a quarter of the difference between actual and implied leverage. Similar tests examining the use of commodity price derivatives also show a significant negative effect on financial risk, whereas the use of FX derivatives is associated with somewhat higher financial risk (perhaps because it serves as a proxy for other unmodeled risks such as those associated with foreign operations or foreign competitors). In sum, the results incorporating the data on financial derivative usage suggests that this type of risk management may explain part, but not a large amount, of the difference between actual and implied leverage.

It is well known that average debt levels vary considerably by industry. This observation poses a challenge for our analysis because we are not able to estimate all of our models with additional parameters (e.g., industry dummy variables). Instead we use the French 17 industry classification to partition our sample and estimate the models at the industry level.[9] Because some industries have a small number of firms in some years, we cannot estimate the LT model year-by-year. However, as shown in Figure A.1, some variables exhibit time-varying relations to asset volatility. Consequently, we estimate pooled regressions, but for only the 1996 to 2009 period. These estimates allow us to compare asset volatility, $LeverageFactors$ and implied leverage across industries as well as with the full sample estimates.

As expected, the results show meaningful variation by industry. For example, asset volatilities range from a low of 0.323 in the fabricated products industry to a high of 0.618 in miscellaneous industries. Overall, the typical values for $LeverageFactors$ and implied leverage are still quite low.[10] Even the largest $LeverageFactor$ (0.57 for fabricated products) is much less than 1.0, and average implied leverage is only 1.12. Negative correlation between σ_A and the $LeverageFactor$ results in variation in implied leverage that is relatively low in comparison. This finding is as would be expected from trade-off theory of capital structure (e.g., the LT model), where firms with riskier assets take on less financial risk. However, the estimated values of the $LeverageFactor$ (all below 1.0) indicate that on average firms reduce effective debt levels more than suggested by the trade-off in the LT model. More importantly, the observed strong negative correlation between σ_A and the $LeverageFactor$ suggests that firms more aggressively find ways to effectively scale back financial risk (in addition to lower actual debt) when they face higher economic risk. As discussed already, this result is again consistent with firms using other risk management tools or dynamic financial policies to reduce financial risks.

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[9] As before, we do not examine utilities or financial services firms, so we are left with 15 industry groups.

[10] Another advantage of conducting the estimation by industry is that it should mitigate problems associated with error measurement of model inputs or even model misspecification. For example, if our low estimates for the $LeverageFactor$ and implied leverage are the result of an errors-in-variables problem at the industry level, we should see average levels of these estimates that are higher. In fact, we do find somewhat higher estimates of the $LeverageFactor$ and implied leverage, but the values are still low compared to 1.0 and actual leverage, respectively. Estimated values for coefficients on other firm-specific factors (not reported) vary significantly by industry, but in almost all cases the significant coefficients have the same sign as those reported in Table 3.

We also present here detailed results for tests referred to but not tabulated in the main text. Table A.8 presents a version of Table 2 with independent sorts on volatility and size. This table shows that the primary results presented in Table 2 are present in both the largest and smallest size quartiles and thus are unlikely to be driven simply by differences in size. Table A.9 presents results from the estimation of the augmented EGARCH model for the full sample with both equity volatility and asset volatility as the dependent variables. Table A.10 provides regression results for the analysis with O-Scores and Z-Scores discussed in Section 6.2.

[**Insert Tables A.8, A.9, and A.10 About Here**]

Table A.1: Sample Construction

The table shows the independent impact of each constraint on our sample size: the number of annual observations lost for each screen; total number of observations lost for all screens combined; and finally the percent of universe market capital of non-financial firms represented in our sample. We consider firms that have annual accounting data in CompuStat for any year between 1964 and 2009 and that have at least 125 non-zero daily stock returns on CRSP for the same year. We exclude utilities and financial services, and apply a variety of screens to focus on only liquidly traded firms in periods of normal operations. Specifically, we exclude 'micro-cap' companies (less than $50 million in market capitalization or $1 million in total assets measured in 2009 dollars) and penny stocks. We also exclude companies in the year of their initial public offering (IPO) and delisting. Firms with some missing or exceptional accounting data and firms likely to be in financial distress are also excluded. For example, we also require the ratio of Cash & STI to Market Capitalization to be between zero and one, Debt/Market Capitalization ratio to be less than one, and Book Value of Equity to be positive. We also only consider firms with estimated annual equity volatilities (standard deviation) that are between 1% and 200%.

	Number of Firm-years	% Lost
Full Sample (CRSP and CompuStat Merged)	114,335	
Firms Lost in Independent Screens		
Real Market Capitalization < $50MM (Year 2009 USD)	30,815	27.0%
Real Total Assets < $1MM (Year 2009 USD)	280	0.2%
Average Price < $1.00	3,682	3.2%
New and Delisted Firms	11,445	10.0%
Missing Variables of Interest	6,571	5.7%
Cash & Short-term Investments / Market Cap > 1	3,642	3.2%
Cash & Short-term Investments < 0	932	0.8%
Debt / Market Cap < 0 or > 10	4,708	4.1%
Debt / Total Assets > 1	3,729	3.3%
Equity (Book Value) < 0	3,846	3.4%
Equity Volatility < 1% or > 200%	1,537	1.3%
Capex > Total Assets	2,016	1.8%
Sales < 0	1,253	1.1%
Firms Lost in Combined Screens	48,113	42.1%
Final Sample	66,222	
Percent of Full Sample Market Cap (annual average)		
including financials and utilities	57.9%	
excluding financials and utilities	90.7%	

Table A.2: Panel Regressions with Firm Characteristics

The table shows coefficient estimates, associated *p*-values (against a null hypothesis of zero), and adjusted R-squareds from panel regressions with firm volatility as the dependent variable. The sample period is from 1964 to 2009. Results are shown for different specifications that include all characteristics, just operating characteristics, and just financial characteristics (with and without dividends). p-values are calculated using standard errors corrected for clustering by firm and year. Total assets is a proxy for firm size. Age is the difference between the measurement year and the minimum of (i) the year of listing data from Jovanovic and Rousseau (2001) and (ii) the firm's initial appearance in the CRSP monthly database. Tangible assets is gross PP&E divided by total assets. Capital expenditures is capital expenditures divided by total assets. Profitability is operating income before depreciation divided by sales. Profit volatility is the five-year central standard deviation of profitability. Dividend yield is common dividends divided by market capitalization (closing price*shares outstanding from CRSP). Total debt/market capitalization is long-term debt plus current liabilities plus preferred stock divided by market capitalization. Cash/market capitalization is cash and short-term investments (STI) divided by market capitalization. Net debt/market capitalization is (total debt – cash & STI) divided by market capitalization. Total debt/total assets (BV) is total debt divided by the sum of total debt and equity book value. Debt maturity is long-term debt divided by total debt. All accounting data items are from CompuStat.

	All Characteristics		Asset Characteristics				Financial Characteristics			
					Including Dividends				Excluding Dividends	
Parameter	Estimate	*p*-value	Estimate	*p*-value	Estimate	*p*-value	Estimate	*p*-value	Estimate	*p*-value
Intercept	0.677	<0.001	0.711	<0.001	0.709	<0.001	0.547	<0.001	0.481	<0.001
Total Assets (log)	-0.015	<0.001	-0.013	<0.001	-0.014	<0.001				
Age (log)	-0.037	<0.001	-0.060	<0.001	-0.040	<0.001				
Tangible Assets	-0.005	0.269	-0.050	<0.001	-0.010	0.028				
Capital Expenditures	-0.062	0.001	-0.030	0.131	-0.118	<0.001				
Profitability	-0.126	<0.001	-0.170	<0.001	-0.186	<0.001				
Profit Volatility	0.560	<0.001	0.605	<0.001	0.497	<0.001				
Dividend Yield	-3.747	<0.001			-3.487	<0.001	-5.659	<0.001		
Total Debt / MktCap	0.042	<0.001					0.029	<0.001	0.011	<0.001
Debt Maturity	-0.072	<0.001					-0.118	<0.001	-0.130	<0.001
Cash / MktCap	0.097	<0.001					0.259	<0.001	0.308	<0.001
Adjusted R^2	0.427		0.337		0.395		0.252		0.066	

Table A.3: Time-Series Model Estimates by Subperiod

This table reports estimated coefficients, p-values and marginal effects for the augmented EGARCH model for various subperiods provided in the column headings. The model being estimated is defined in the main text in equations (3-4). Marginal effects (ME) are changes in volatility for a one standard deviation change in the firm characteristic. Estimation is conducted using the pooled sample of quarterly returns. Firm Characteristics are the same as those defined in the header of Table 4. Tax Rate is the statutory rate for the highest corporate income group as reported by The Tax Foundation. CFNAI is the Chicago Federal Reserve's National Activity Index.

	1964–1973			1974–1981			1982–1990			1991–2000			2001–2009		
	Est.	p-value	ME	Est.	p-value	ME	Est.	p-value	ME	Est.	p-value	ME	Est.	p-value	ME
<u>EGARCH Parameters</u>															
c	-0.268	0.219		-0.465	0.092		-0.406	<.001		-0.286	0.056		-0.302	<.001	
α	0.164	<.001		0.166	<.001		0.169	<.001		0.388	<.001		0.304	<.001	
β	0.714	<.001		0.753	<.001		0.839	<.001		0.823	<.001		0.823	<.001	
γ	-0.055	<.001		-0.110	<.001		-0.037	<.001		-0.154	<.001		-0.093	<.001	
<u>Firm Characteristics</u>															
Total Assets (log)	-0.054	<.001	-0.010	-0.055	<.001	-0.012	-0.023	<.001	-0.007	-0.035	<.001	-0.014	-0.049	<.001	-0.012
Age (log)	-0.023	0.012	-0.002	-0.009	0.174	-0.001	-0.020	<.001	-0.003	0.008	0.001	0.002	-0.015	<.001	-0.002
Tangible Assets	-0.056	0.049	-0.004	-0.043	0.036	-0.003	0.014	0.037	0.001	-0.002	0.724	-0.000	0.028	0.003	0.003
Capital Expenditures	0.170	0.271	0.002	-0.057	0.605	-0.001	-0.051	0.200	-0.001	-0.356	<.001	-0.006	0.068	0.256	0.001
Profitability	-0.423	<.001	-0.011	0.191	0.003	0.006	-0.131	<.001	-0.005	0.042	0.031	0.002	0.011	0.613	0.000
Profit Volatility	1.154	<.001	0.027	0.678	<.001	0.019	0.233	<.001	0.007	0.721	<.001	0.029	0.399	<.001	0.014
Dividend Yield	-3.353	<.001	-0.007	-2.691	<.001	-0.006	-2.123	<.001	-0.006	-4.960	<.001	-0.017	-2.691	<.001	-0.008
Total Debt/Market Cap	0.067	<.001	0.010	0.045	<.001	0.008	0.043	<.001	0.009	0.033	<.001	0.009	0.096	<.001	0.023
Cash/Market Cap	-0.067	0.465	-0.001	0.083	0.006	0.002	-0.048	<.001	-0.001	0.010	0.482	0.000	0.100	<.001	0.003
Debt Maturity	0.141	<.001	0.005	-0.161	<.001	-0.009	0.029	0.004	0.002	0.051	<.001	0.004	0.055	<.001	0.004
<u>Macro Characteristics</u>															
Tax Rate	-0.579	0.145	-0.002	0.465	0.420	0.001	0.242	<.001	0.003						
CFNAI	-0.085	<.001	-0.013	-0.096	<.001	-0.024	-0.120	<.001	-0.023	-0.051	<.001	-0.007	-0.114	<.001	-0.027

Table A.4: Reduced Form Model

The table reports coefficient estimates and p-values from the estimate of the reduced form (RF) model. Results are shown separately for pooled and Fama-MacBeth regressions for the sample between 1964 and 2009. The table also provides predicted values and standard deviations for σ_A (volatility of assets) and Market Leverage as defined in Equations A.11 and A.12. p-values are calculated using standard errors corrected for clustering at the firm level and by year. Firm Characteristics are defined in the header of Table 3. All accounting data items are from CompuStat.

	Pooled Sample		Fama-MacBeth	
Parameter	Estimate	p-value	Mean	p-value
σ_A				
Intercept	0.672	<0.001	0.651	<0.001
Total Assets (log)	-0.015	<0.001	-0.030	<0.001
Age (log)	-0.038	<0.001	-0.017	<0.001
Tangible Assets	-0.008	0.003	-0.010	0.113
Capital Expenditures	-0.053	<0.001	0.037	0.179
Profitability	-0.155	<0.001	-0.116	<0.001
Profit Volatility	0.657	<0.001	0.618	<0.001
Dividend Yield	-3.261	<0.001	-2.373	<0.001
Financial Leverage (l)				
Total Debt / Market Cap	0.059	<0.001	0.103	0.009
Total Debt / Market Cap * σ_A	0.046	0.001	-0.097	0.401
Cash / Market Cap	0.626	<0.001	-0.021	0.850
Cash / Market Cap * σ_A	-0.718	<0.001	0.611	0.089
Debt Maturity	-0.037	0.030	-0.021	0.754
Debt Maturity * σ_A	-0.200	<0.001	0.154	0.443
Dividends (restricted to ≥ 0)	0.000		0.000	

Implied Values	Mean	Std. Dev.	Mean	Std. Dev.
σ_A	0.474	0.162	0.421	0.129
Market Leverage	1.047	0.102	1.085	0.065

Table A.5: Leland-Toft Model Estimation Results - Alternative Growth Option Proxy

The table shows Leland Toft (LT) model coefficient estimates, p-values, and marginal effects from pooled and Fama-MacBeth regressions for the sample between 1964 and 2009. The table also provides predicted values and standard deviations for σ_A (volatility of assets) and Implied Financial Leverage (l) as defined in Equations 5 and 2. Marginal effects are defined as the change in total risk resulting from a one-standard deviation increase (from the mean) in the independent variable, with other independent variables set to their mean values. Total assets is a proxy for firm size. Age is the difference between the measurement year and the minimum of (i) the year of listing data from Jovanovic and Rousseau (2001) and (ii) the firm's initial appearance in the CRSP monthly database. Tangible assets is gross PP&E divided by total assets. Market / Book is total liabilities plus market value of equity scaled by total assets. Profitability is operating income before depreciation divided by sales. Profit volatility is the five-year central standard deviation of profitability. Dividend yield is common dividends divided by market capitalization (absolute value of closing price*shares outstanding from CRSP). $LeverageFactor$ is defined in Equation 7. All accounting data items are from CompuStat.

	Pooled Sample			Fama-MacBeth		
Parameter	Estimate	p-value	ME	Mean	p-value	ME
Intercept (β_0)	-0.15	<0.001		-0.16	0.002	
Total Assets (log)	-0.05	<0.001	-0.087	-0.10	<0.001	-0.173
Age (log)	-0.07	<0.001	-0.063	-0.03	<0.001	-0.027
Tangible Assets	-0.07	<0.001	-0.026	-0.03	0.010	-0.011
Market to Book	-0.02	<0.001	-0.026	-0.04	<0.001	-0.052
Profitability	-0.27	<0.001	-0.050	-0.21	<0.001	-0.039
Profit Volatility	0.70	<0.001	0.085	0.98	<0.001	0.120
Dividend Yield	-10.70	<0.001	-0.203	-8.50	<0.001	-0.162
Leverage Factor	0.09	<0.001		0.23	<0.001	

Implied Values	Mean	Std. Dev.		Mean	Std. Dev.	
σ_A	0.470	0.162		0.406	0.113	
Implied Financial Leverage (l)	1.024	0.029		1.082	0.057	

Table A.6: Time-Series Model Estimates - Alternative Growth Option Proxy

This table reports estimated coefficients, p-values, and marginal effects for the Augmented EGARCH model as defined in equations (3-4). We restrict this sample period to the years 1991-2008 examined in Choi and Richardson. Marginal effects (ME) are changes in volatility for a one standard deviation change in the firm characteristic calculated while holding other variables at their sample mean. Asset returns used to estimate the asset volatility model are derived from dividing equity returns by (1 + debt/equity). Estimation is conducted using the pooled sample of quarterly returns. Firm Characteristics are defined in the header of Table 4 with the exception of Market / Book, which is defined as total liabilities plus market value of equity scaled by total assets. CFNAI is the Chicago Federal Reserve's National Activity Index.

	Equity Volatility			Asset Volatility		
	Estimate	p-value	ME	Estimate	p-value	ME
EGARCH Parameters						
c	-0.325	<0.001		-0.589	<0.001	
α	0.334	<0.001		0.358	<0.001	
β	0.825	<0.001		0.777	<0.001	
γ	-0.109	<0.001		-0.077	<0.001	
Firm Characteristics						
Total Assets (log)	-0.030	<0.001	-0.010	-0.045	<0.001	-0.011
Age (log)	-0.014	<0.001	-0.002	-0.014	<0.001	-0.002
Tangible Assets	-0.004	0.350	-0.000	0.019	<0.001	0.001
Market / Book	0.018	<0.001	0.006	0.048	<0.001	0.011
Profitability	-0.014	0.269	-0.001	0.053	<0.001	0.002
Profit Volatility	0.219	<0.001	0.008	0.307	<0.001	0.008
Dividend Yield	-3.120	<0.001	-0.009	-4.566	<0.001	-0.010
Total Debt / Market Cap	0.042	<0.001	0.010	-0.077	<0.001	-0.012
Cash / Market Cap	0.057	<0.001	0.002	0.141	<0.001	0.003
Debt Maturity	0.013	0.060	0.001	0.085	<0.001	0.004
Macro Characteristics						
CFNAI	-0.069	<0.001	-0.012	-0.061	<0.001	-0.008
Number of Firms	2,151			2,151		

Table A.7: Time-Series Model Estimates using Idiosyncratic Returns

This table reports estimated coefficients, p-values, and marginal effects for the Augmented EGARCH model as defined in equations (3-4). We restrict this sample period to the years 1991-2008 examined in Choi and Richardson. Marginal effects (ME) are changes in volatility for a one standard deviation change in the firm characteristic calculated while holding other variables at their sample mean. Idiosyncratic equity returns are the residuals from firm-by-firm regressions of equity returns on the three Fama-French factors. Asset returns used to estimate the asset volatility model are derived from dividing equity returns by (1 + debt/equity). Estimation is conducted using the pooled sample of quarterly returns. Firm Characteristics are defined in the header of Table 4. CFNAI is the Chicago Federal Reserve's National Activity Index.

	Equity Volatility			Asset Volatility		
	Estimate	p-value	ME	Estimate	p-value	ME
EGARCH Parameters						
c	-0.233	<0.001		-0.427	<0.001	
α	0.316	<0.001		0.375	<0.001	
β	0.875	<0.001		0.813	<0.001	
γ	-0.088	<0.001		-0.080	<0.001	
Firm Characteristics						
Total Assets (log)	-0.033	<0.001	-0.011	-0.059	<0.001	-0.014
Age (log)	-0.005	0.007	-0.001	0.000	0.931	0.000
Tangible Assets	0.003	0.477	0.000	0.047	<0.001	0.003
Capital Expenditures	-0.004	0.895	-0.000	-0.290	<0.001	-0.003
Profitability	-0.004	0.736	-0.000	0.118	<0.001	0.003
Profit Volatility	0.345	<0.001	0.012	0.655	<0.001	0.016
Dividend Yield	-2.728	<0.001	-0.008	-5.043	<0.001	-0.011
Total Debt / Market Cap	0.043	<0.001	0.010	-0.041	<0.001	-0.007
Cash / Market Cap	0.006	0.519	0.000	0.005	0.637	0.000
Debt Maturity	0.044	<0.001	0.003	0.141	<0.001	0.007
Macro Characteristics						
CFNAI	-0.034	<0.001	-0.006	-0.038	<0.001	-0.005
Number of Firms	2,151			2,151		

Table A.8: Means of Variables by Sorts on Volatility and Size

The table reports means of equity volatility, economic risk, and financial risk factors by independent sorts on volatility and size quartiles for the sample of annual observations between 1964 and 2009. We report results for the corner portfolios only. Equity volatility is annualized standard deviation of daily stock returns from CRSP. Total assets is a proxy for firm size. Age is the difference between the measurement year and the minimum of (i) year of listing data from Jovanovic and Rousseau (2001) and (ii) the firm's initial appearance on CRSP monthly database. Tangible Assets is gross PP&E divided by total assets. Capital expenditures is capital expenditures divided by total assets. Profitability is operating income before depreciation divided by sales. Profit volatility is the five-year central standard deviation of profitability. Dividend yield is common dividends divided by market capitalization (absolute value of closing price*shares outstanding from CRSP). Total debt/market capitalization is long-term debt plus current liabilities plus preferred stock divided by market capitalization. Cash/market capitalization is cash and short-term investments (STI) divided by market capitalization. Net debt/market capitalization is (total debt – cash & STI) divided by market capitalization. Total debt/total assets (BV) is total debt divided by the sum of total debt and equity book value. Debt maturity is long-term debt divided by total debt. Coupon rate is interest expense plus preferred dividends divided by total debt. All accounting data items are from CompuStat.

	Low Vol × Small	Low Vol × Large	High Vol × Small	High Vol × Large
Equity Volatility (annualized)	0.240	0.239	0.843	0.803
Total Assets (MM)	49.8	7,969.3	40.4	4,219.1
Age (years)	15.6	37.8	7.9	19.4
Tangible Assets	0.565	0.709	0.385	0.530
Capital Expenditures	0.068	0.074	0.067	0.069
Profitability	0.143	0.177	-0.097	0.124
Profit Volatility	0.027	0.019	0.219	0.079
Dividend Yield	0.032	0.026	0.002	0.006
Total Debt / Market Capitalization	0.453	0.671	0.331	1.489
Total Debt / Total Assets (BV)	0.328	0.453	0.344	0.478
Cash / Market Capitalization	0.140	0.080	0.173	0.197
Net Debt / Market Capitalization	0.313	0.591	0.159	1.292
Debt Maturity	0.280	0.446	0.215	0.486
Coupon Rate	0.027	0.040	0.030	0.039

Table A.9: Time-Series Model Estimates

This table reports estimated coefficients, p-values, and marginal effects for the Augmented EGARCH model as defined in equations (3-4). We restrict this sample period to the years 1991-2008 examined in Choi and Richardson. Marginal effects (ME) are changes in volatility for a one standard deviation change in the firm characteristic calculated while holding other variables at their sample mean. Asset returns used to estimate the asset volatility model are derived from dividing equity returns by (1 + debt/equity). Estimation is conducted using the pooled sample of quarterly returns. Firm Characteristics are defined in the header of Table 4. CFNAI is the Chicago Federal Reserve's National Activity Index.

	Equity Volatility			Asset Volatility		
	Estimate	p-value	ME	Estimate	p-value	ME
EGARCH Parameters						
c	-0.216	<0.001		-0.396	<0.001	
α	0.363	<0.001		0.392	<0.001	
β	0.835	<0.001		0.780	<0.001	
γ	-0.127	<0.001		-0.098	<0.001	
Firm Characteristics						
Total Assets (log)	-0.040	<0.001	-0.016	-0.062	<0.001	-0.018
Age (log)	-0.005	0.004	-0.001	-0.006	0.006	-0.001
Tangible Assets	0.011	0.029	0.001	0.044	<0.001	0.004
Capital Expenditures	-0.180	<0.001	-0.003	-0.445	<0.001	-0.005
Profitability	-0.056	<0.001	-0.003	0.017	0.277	0.001
Profit Volatility	0.566	<0.001	0.023	0.900	<0.001	0.027
Dividend Yield	-3.664	<0.001	-0.013	-5.992	<0.001	-0.015
Total Debt / Market Cap	0.046	<0.001	0.012	-0.052	<0.001	-0.010
Cash / Market Cap	-0.010	0.348	-0.000	-0.020	0.105	-0.001
Debt Maturity	0.050	<0.001	0.004	0.154	<0.001	0.009
Macro Characteristics						
CFNAI	-0.054	<0.001	-0.011	-0.041	<0.001	-0.006
Number of Firms	2,151			2,151		

Table A.10: Risk Management and Measures of Financial Distress

This table reports estimated coefficients, p-values, and marginal effects for the regression of risk management on the difference between percentile O-Score and percentile Z-Score. O-Score is calculated as in Ohlson (1980) and is multiplied by -1 to match the sign of Z-Score. Z-Score is calculated as in Altman (1968). In the first set of results, risk management is the difference between actual leverage and implied leverage from the Leland Toft (LT) estimation. In the second set of results, risk managment is the percentile difference between actual leverage and implied leverage from the LT estimation. Marginal effects (ME) are changes in the difference between percentile O-Score and percentile Z-Score for a one standard deviation change in the risk management measure. Observations are firm-years, and standard errors are clustered by firm.

	Est.	p-value	ME
Actual Leverage - Implied Leverage	3.481	<0.001	4.794
w/ Year Fixed Effects	3.385	<0.001	4.661
Ranked by Year	3.198	<0.001	4.404
Actual Leverage - Implied Leverage Percentile	0.307	<0.001	8.853
w/ Year Fixed Effects	0.315	<0.001	9.099
Ranked by Year	0.305	<0.001	8.783

Figure A.1: Annual Leland-Toft Model Coefficient Estimates

The figure plots the annual coefficient estimates for each of the variables in the Fama-MacBeth version of the Leland-Toft model estimation. Coefficients (dark lines) are from estimations done each year from 1964 to 2008. 95% confidence bounds are indicated by lighter lines. Estimates are reported for total assets (log), age (log), tangible assets, capital expenditures, profitability, profit volatility, dividend yield, and the *LeverageFactor* (as defined in Equation 7). NBER-dated recessions are shaded in gray.

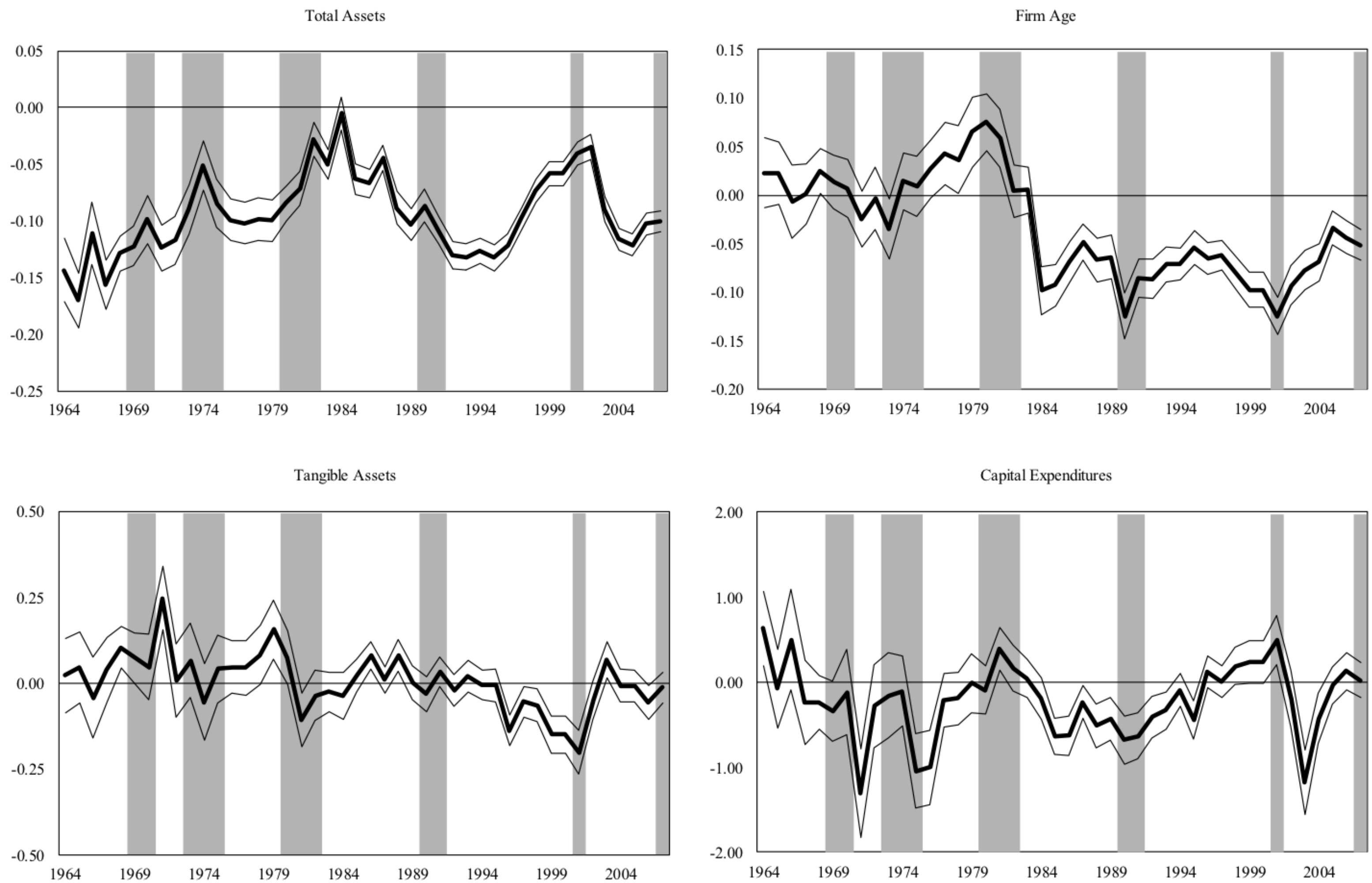

Figure A.1: Annual Leland-Toft Model Coefficient Estimates (cont.)