Internet Appendix for How Important is Financial Risk?

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I. Leland-Toft Model

In this appendix 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:

$$
d(V;VB,t) = \frac{c(t)}{r} + e^{-rt}[p(t) - \frac{c(t)}{r}][1-F(t)] + [\rho(t)VB - \frac{c(t)}{r}]G(t),
$$

$$
F(t) = N(h_1(t)) + (\frac{V}{VB})^{-2a}N(h_2(t)),\ G(t) = (\frac{v}{VB})^{-a+z}N(q_1(t)) + (\frac{V}{VB})^{-a-z}N(q_2(t)),
$$

(A.3)

$$
q_1(t) = (\frac{-b - zt\sigma_A^2}{\sigma_A\sqrt{t}}),\ q_2(t) = (\frac{-b + zt\sigma_A^2}{\sigma_A\sqrt{t}}),\ h_1(t) = (\frac{-b - at\sigma_A^2}{\sigma_A\sqrt{t}}),\ h_2(t) = (\frac{-b + at\sigma_A^2}{\sigma_A\sqrt{t}}),
$$

$$
a = \frac{r - \delta - 0.5\sigma_A^2}{\sigma_A^2},\ b = \log(\frac{V}{VB}),\ z = \frac{\sqrt{(a\sigma_A^2)^2 + 2r\sigma_A^2}}{\sigma_A^2},\ x = a + z.
$$

$N(\cdot)$ 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

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

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:

$$\text{(A.6)}\quad E(V;VB;T) = v(V;VB;T) - D(V;VB;T).$$

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

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

The smooth pasting condition gives the following bankruptcy trigger:

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

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

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

II. Sample Construction and Additional Tests

In this appendix we discuss 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

[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.

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 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

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

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

[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

[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.

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.

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

[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.

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.

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

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 $LeverageFactor$. 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

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

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

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

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

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

and, we define market leverage as

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

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 B.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.

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

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.

We also present here detailed results for tests referred to but not tabulated in the main text.

[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.

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%.

Table A.1: Sample Construction (cont.)

	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.

Table A.2: Panel Regressions with Firm Characteristics (cont.)

	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
EGARCH Parameters															
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	
Firm Characteristics															
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
Macro Characteristics															
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.

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

	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.

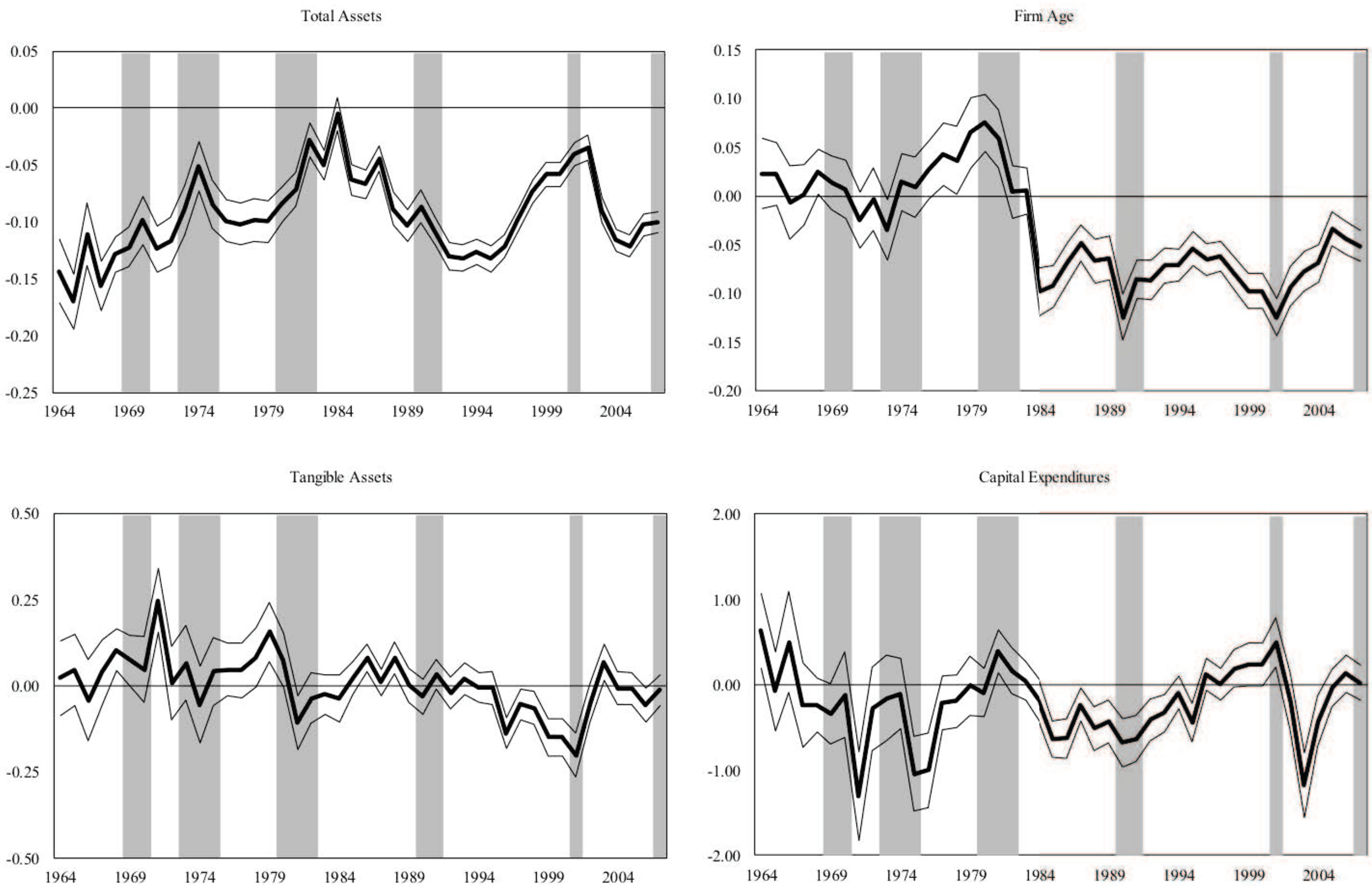

Figure A.1: Annual Leland-Toft Model Coefficient Estimates (cont.)