Leverage Effects in Stock Return Volatility:

A China – US Comparison

by

Xuyou Zhang

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Professor Marti G. Subrahmanyam
Professor Christina Wang
Professor Wendy Jin

Faculty Advisers

Professor Jennifer N. Carpenter

Thesis Adviser

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Abstract

It is believed that a fall in stock price will lead to an increase in stock return volatility. As a negative change in stock price essentially increases the leverage in a firm's capital structure, the negative relation between stock returns and volatility is called the "leverage effect". This paper aims to compare the leverage effects in the Chinese and US stock markets. Using quarterly data from 2001Q4 to 2019Q4, this paper finds that the so-called "leverage effect" is more a US phenomenon, especially in the down market and what is believed to be "leverage effect" is actually not associated with firm's capital structure. I also find evidence of dynamic trading volume, dynamic corporate investment and financing policies that confound these leverage effects.

1 Introduction

Stock return volatility was once called the "cornerstone" of the theory of modern finance (Figlewski and Wang 2000). The determinants of stock return volatility have been studied widely. I analyze leverage effects in stock return volatility. The leverage effect refers to a negative relation between stock returns and volatility. Christie (1982) attributes the negative elasticity of volatility with respect to stock price to financial leverage. However, scholars hold different opinions about the importance of financial leverage on stock return volatility. Figlewski and Wang (2000) find evidence of an asymmetry in leverage effects in up and down markets and argue that the leverage effect is not permanent but will fade away over time. Choi and Richardson (2016), on the other hand, claim that financial leverage has a permanent effect on equity volatility.

Previous studies on leverage effects in stock return volatility mainly use US stock market data. However, given the unique features of the Chinese stock market, we may expect to see some different results than those of studies conducted on the US stock market. In this paper, I compare the leverage effects between China and US in a more recent time period.

2 Background and Hypothesis Development

As in Christie (1982), it is convenient to analyze the elasticity of stock return volatility with respect to the stock price, which we call θ. We look at two models. Riskless debt and risky debt in a Black-Scholes-Merton model.

For riskless debt we copy here the derivation of Christie. From a firm balance sheet, we know that $V = D + S$, where V is the total amount of firm assets, D is the present value of debt and S is the amount of equity. Given that the debt is riskless, $V > D$, and stockholders for sure get $S = V - D$. In this case, D is non-stochastic. Thus we get:

$$dS{=}dV + \text{dt terms}$$

where the "dt terms" do not contribute to volatility. Ignoring the "dt terms" and dividing both sides by S,

$$\tfrac{dS}{S} = \tfrac{dV}{S} = \tfrac{dV}{V} \cdot \tfrac{V}{S}.$$

Hence, we can get:

$$\sigma_S = \sigma_V \cdot \tfrac{V}{S} = \sigma_V \cdot \tfrac{S+D}{S} = \sigma_V(1 + \tfrac{D}{S}).$$

By taking the partial derivative, we get:

$$\tfrac{\partial \sigma_S}{\partial S} = \sigma_V \cdot D(\tfrac{-1}{S^2})$$

The elasticity in the riskless debt case, θ_0, will be:

$$\theta = \tfrac{\partial \sigma_S/\sigma_S}{\partial S/\sigma_S} = \tfrac{\partial \sigma_S}{\partial S} \times \tfrac{S}{\sigma_S} = \tfrac{-D/S}{1+D/S} = -\tfrac{D}{V}$$

As we can see from the final expression for the elasticity, though σ_S is a function of σ_V, the elasticity expression depends solely on the leverage level of the firm.

Now, consider the case of risky debt. Suppose debt is a zero-coupon bond with face value K, maturing at time T as in Merton (1974). If the firm is doing well, then at the time when the debt matures, $V \geq K$, the firm is able to pay off the debt holders and stockholders get $V - K$. However, if the firm does poorly and cannot pay back the debt, the stockholders get zero. Thus, S can be viewed as a call option on the assets of a firm, with strike price K and expiration at time T.

According to the Black-Scholes-Merton model:

$$S = VN(d_1) - Ke^{-rT}N(d_2)$$

where:

$$d_1 = \frac{\ln{(V/Ke^{-rT})}}{\sigma\sqrt{T}} + \frac{1}{2}\sigma\sqrt{T} \text{ and } d_2 = d_1 - \sigma\sqrt{T}$$

It follows that $\frac{\partial S}{\partial V} = N(d_1)$. The detailed derivation is as follows:

$$\frac{\partial S}{\partial V} = 1 \times N(d_1) + V \times [\frac{\partial N(d_1)}{\partial V}] - Ke^{-rT} \times [\frac{\partial N(d_2)}{\partial V}]$$

By applying the chain rule, I get:

$$\frac{\partial S}{\partial V} = N(d_1) + V \times N'(d_1)\frac{\partial d_1}{\partial V} - Ke^{-rT} \times N'(d_2)\frac{\partial d_2}{\partial V}$$

Note that $\frac{\partial d_1}{\partial V}$ and $\frac{\partial d_2}{\partial V}$ are the same because $d_2 = d_1 - \sigma\sqrt{T}$. In addition, $N'(d_1) = \frac{1}{\sqrt{2\pi}}e^{\frac{-d_1^2}{2}}$ and $N'(d_2) = \frac{1}{\sqrt{2\pi}}e^{\frac{-d_2^2}{2}}$. Hence, factoring out the common part:

$$\frac{\partial S}{\partial V} = N(d_1) + \frac{1}{\sqrt{2\pi}} \times \frac{\partial d_1}{\partial V}(Ve^{\frac{-d_1^2}{2}} - Ke^{-rT}e^{\frac{-d_2^2}{2}})$$

Next, I will prove that the value of the term in parentheses is zero. First, substitute d_2 for $d_1 - \sigma_V\sqrt{T}$:

$$\begin{aligned}
Ve^{\frac{-d_1^2}{2}} - Ke^{-rT}e^{\frac{-d_2^2}{2}} &= Ve^{\frac{-d_1^2}{2}} - Ke^{-rT}e^{\frac{-(d_1-\sigma\sqrt{T})^2}{2}} && (1)\\
&= Ve^{\frac{-d_1^2}{2}} - Ke^{-rT}e^{\frac{-d_1^2}{2} - \frac{\sigma_V^2}{2} + \sigma_V\sqrt{T}d_2} && (2)\\
&= e^{\frac{-d_1^2}{2}} \times [V - e^{-rT}Ke^{-\sigma_V^2\frac{T}{2} + \ln\frac{V}{e^{-rT}K} + \frac{\sigma_V^2 T}{2}}] && (3)\\
&= e^{\frac{-d_1^2}{2}}[V - e^{-rT}Ke^{\ln\frac{V}{e^{-rT}K}}] && (4)\\
&= e^{\frac{-d_1^2}{2}}[V - e^{-rT} \cdot \frac{V}{e^{-rT}K}] && (5)\\
&= 0 && (6)
\end{aligned}$$

Now given that $\frac{\partial S}{\partial V} = N(d_1)$, it follows from Itô's lemma that:

$$\frac{dS}{S} = \frac{dV}{V} \cdot N(d_1) \cdot \frac{V}{S} + \text{dt terms}$$

Since the "dt terms" here do not affect the volatility but only affect the appreciation rate, they will be ignored and we get:

$$\sigma_S = \sigma_V \cdot N(d_1) \cdot \frac{V}{S}$$

The elasticity $\theta = \frac{\partial \sigma_S/\sigma_S}{\partial S/\sigma_S} = \frac{\partial \sigma_S}{\partial S} \times \frac{S}{\sigma_S}$. I already have expressions for $S(V)$ and $\sigma_S(V)$, so I need to do now compute $\frac{\partial \sigma_S}{\partial S}$. By the Inverse Function Theorem, $\frac{\partial \sigma_S}{\partial S} = \frac{\partial \sigma_S/\partial V}{\partial S/\partial V}$. We already have $\partial S/\partial V = N(d_1)$. It remains to compute $\frac{\partial \sigma_S}{\partial V}$.

$$\frac{\partial \sigma_S}{\partial V} = \sigma_V \cdot N'(d_1) \cdot \frac{\partial d_1}{\partial V} \cdot \frac{V}{S} + \sigma_V \frac{N(d_1)}{S} + \sigma_V N(d_1) V(-\frac{1}{s^2}) \cdot \frac{\partial S}{\partial V} \tag{7}$$

$$= \sigma_V [N'(d_1) \frac{1}{V \sigma V \sqrt{T}} \cdot \frac{V}{S} + \frac{N(d_1)}{S} - N(d_1) \frac{V}{S^2} \cdot \frac{\partial S}{\partial V}] \tag{8}$$

$$= \frac{N'(d_1)}{S\sqrt{T}} + \sigma_V \frac{N(d_1)}{S} - \sigma_V N(d_1)^2 \cdot \frac{V}{S^2} \tag{9}$$

Now that we have $\frac{\partial \sigma_S}{\partial V}$:

$$\frac{\partial \sigma_S}{\partial S} = \frac{N'(d_1)}{SN(d_1)\sqrt{T}} + \frac{\sigma V}{S} - \sigma_V N(d_1) \cdot \frac{V}{S^2}$$

$$\frac{S}{\sigma_S} = \frac{S}{[\sigma_V N(d_1) V/S]} = \frac{S^2}{\sigma_V N(d_1) V}$$

Thus,

$$\theta = \frac{\partial \sigma_S}{\partial S} \cdot \frac{S}{\sigma_S} \tag{10}$$

$$= \frac{SN'(d_1)}{\sigma_V \sqrt{T} N(d_1)^2 V} + \frac{S}{N(d_1)V} - 1 \tag{11}$$

$$= \frac{S}{VN(d_1)} \cdot [\frac{N'(d_1)}{N(d_1)\sigma_V\sqrt{T}} + 1] - 1 \tag{12}$$

Numerical examples suggest that, for empirically plausible levels of leverage and asset volatility, the elasticity in the risky debt case is negative and monotonically increasing to 0 as V goes to infinity. In addition, it appears that for $V > D$, $\theta \to \theta_0$ as $\sigma_V \to 0$.

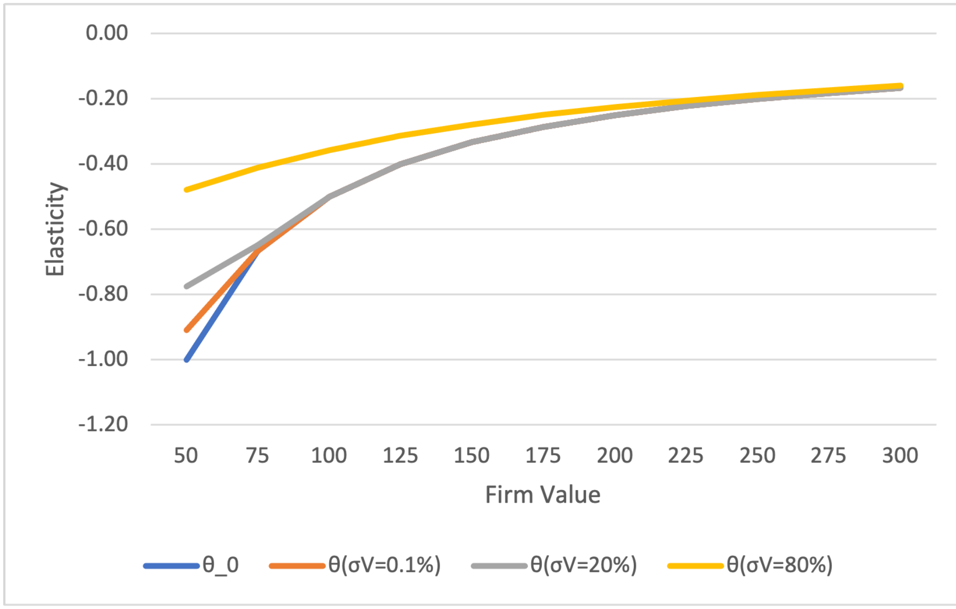

Figure 1: Plots of elasticity θ vs. firm value for various values of σ_V. The other parameter values are $r = 0, T = 1, K = 50$

This motivates my hypothesis that the elasticity of equity volatility is decreasing in leverage. To test this, I propose to run the following quarterly panel regression. First, I will run a "naive" direct regression of stock volatility on leverage:

$$\ln \hat{\sigma}_{it+1} = \alpha + \beta \ln \frac{V_{it}}{E_{it}} + \varepsilon_{it+1} \tag{13}$$

Here the hypothesis is that $\beta > 0$. As indicated in Choi and Richardson (2016), this model fails to control for firm asset volatility, which in the US is negatively related to firm leverage as Leland's (1994) theory of optimal capital structure would suggest. The resulting U-shaped equity volatility pattern from Figure 2, copied from Choi and Richardson (2016), suggests that without controlling asset volatility, leverage has little explanatory power for stock return volatility. Previous studies witness a zero or negative relation when not controlling for asset volatility (e.g., Brandt, Brav, Graham, and Kumar, 2010; Chun, Kim, Morck, and Yeung, 2008). Thus, the R^2 in this regression may be low. However, as the Chinese stock market has a different listing standard, imposes limits on daily price changes, and contains many state-backed firms, the results of the regression in equation (13) may be different in China than in the US. For example, implicit guarantees on state-backed firms may make debt less risky and lead to a more pronounced leverage effect in volatility. On the other hand, daily price change limits may dampen volatility and obscure the leverage effects.

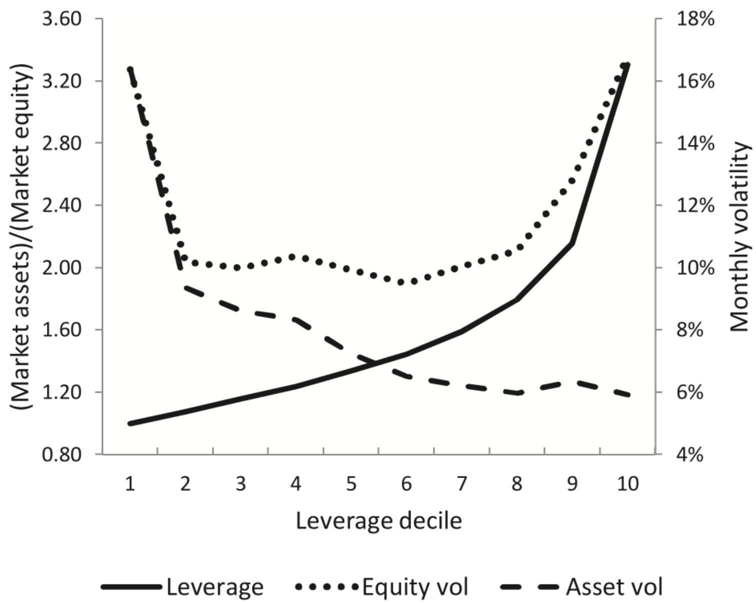

Figure 2: Asset and equity volatility across leverage deciles (Choi and Richardson, 2016)

Second, as in Christie (1982), I would like to estimate the elasticity of stock volatility with respect to the stock price as the coefficient in a regression of the change of the natural log of stock volatility on the change in the natural log of the stock price. Christie's regression model is:

$$\ln\left(\frac{\hat{\sigma}_{it}}{\hat{\sigma}_{it-1}}\right) = \alpha + \theta\left[\ln\left(\frac{S_{it}}{S_{it-1}}\right)\right] + u_{it} \tag{14}$$

Christie regressed the stock return on the realized volatility over the same time period. However, contemporaneous stock returns and volatility may be correlated (Chou, 1988). To eliminate the impact of the overlaps of quarterly stock returns and volatility estimates in calendar time, I modify the dependent variable in equation (14) as follows:

$$\ln{(\frac{\hat{\sigma}_{it+1}}{\hat{\sigma}_{it-1}})} = \alpha + \theta[\ln{(R_{it})}] + u_{it+1} \tag{15}$$

Here, R_{it} is the quarterly stock return which essentially is the same as $\frac{S_{it+1}}{S_it}$ and it is calculated by cumulating daily stock returns. Based on the theory above, I hypothesize that $-1 < \theta < 0$.

Finally, based on the theory above, I extend the Christie regression to allow the elasticity estimate to be a function of leverage $\frac{D}{V}$:

$$\ln{(\frac{\hat{\sigma}_{it+1}}{\hat{\sigma}_{it-1}})} = \alpha + [\gamma_0 + \gamma_1(\frac{D_{it-1}}{V_{it-1}})][\ln R_{it}] + \gamma_2(\frac{D_{it-1}}{V_{it-1}}) + n_{it+1} \tag{16}$$

The hypothesis is that $\gamma_1 < 0$.

3 Data Collection and Winsorization

I obtain data on all Chinese A-Share listed companies over the 18-year period from January 2002 to December 2019 from WIND. As for variables for US-listed companies, stock transaction data are obtained from CRSP and company accounting data are obtained from Compustat. Daily stock returns obtained from WIND and CRSP are used to estimate quarterly volatility for all stocks. And I use the market value of equity, and the book value of debt for leverage related variables.

I construct panel data sets to run the aforementioned regressions. Following Liu, Stambaugh and Yuan (2019), I exclude stocks that (1) have been listed for less than 6 months, (2) have fewer than 120 trading records in the past year and (3) have fewer than 15 trading records in the most recent month of the sample period. In addition, I also eliminate financial firms because of their extreme leverage ratios. The application of these filters provides a final sample of 3503 Chinese stocks and 4148 US stocks.

In the original data set, the maximum values of the variables are more than five standard deviations away from their means. For instance, the scatter plot attached below shows there are extreme values on the upper ends of both Volatility and Leverage Ratio1, defined as (Market Value of Equity + Long-term Debt + Short-term Debt)/Market Value of Equity.

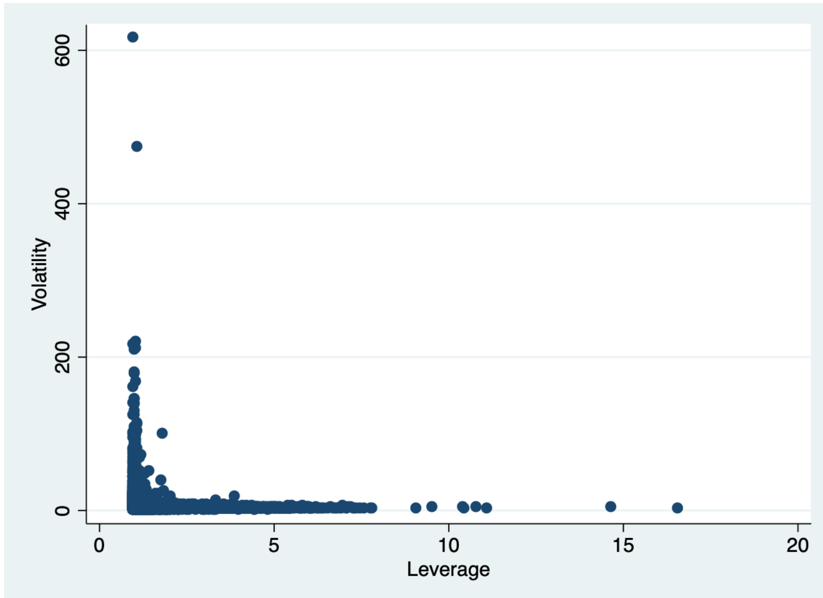

Figure 3: Scatter Plot of Original Variables

To reduce the impact of outliers in the regression models, I first winsorize the data by replacing observations of Leverage and Volatility that are greater than their $99th$ percentile with their corresponding $99th$ percentile value. I also winsorize the lower end of Volatility by substituting observations smaller than the $1st$ percentile with the $1st$ percentile value. Stock return variables are not winsorized. Table 1 shows the summary statistics of all the winsorized variables of China and US, respectively.

4 Direct Regression of Stock Volatility on Leverage

For regression (13), leverage is defined as (Market Value of Equity + Short-term Debt + Long-term Debt)/Market Value of Equity. The regression results for both Chinese and US Stocks are shown in Table 2. Though in my sample period, there are more US firms included than China, here, there are fewer observations in the US. Chinese firms report their financial statements based on calendar quarters, while in the US, not all companies' fiscal year align with the calendar year. When balance sheet data are gathered from Compustat, US companies whose fiscal year does not align with the calender year will report a missing value and observations contain missing values are eliminated.

The "naive" hypothesis is that stock return volatility will increase with an increase in the leverage ratio. From Panel A, we see $\beta < 0$ for China, indicating a negative relation between stock return volatility and financial leverage. But a negative β result is not that surprising, Brandt, Brav, Graham, and Kumar (2010), Chun, Kim, Morck, and Yeung (2008), and Wei and Zhang (2006) have seen zero or even negative coefficients when regressing idiosyncratic volatility on leverage. In contrast, from the "naive" regression, a leverage effect can be witnessed in the US as its $\beta > 0$. Both R^2s' are low. Choi and Richardson (2016) attribute the low explanatory power of leverage on equity volatility to the fact that leverage and asset volatility are negatively related as is shown in Figure 2.

In Panel B, the signs of median βs of firm by firm time-series regressions for China and US align with the panel regression results. For example, both mean βs are negative.

5 Elasticity of Volatility with Respect to Stock Return

Next, I estimate regression (15). I apply additional data filters to eliminate quarters with trading suspensions. The regression result is reported in Table 3. The panel regression results for both countries are consistent with what the "naive" regressions show. It seems that the leverage effect exists in the US but not in China. The elasticity θ for Chinese stock is 0.22, falling outside of the hypothesized range of $-1 < \theta < 0$. The signs of the mean and median θ for firm-by-firm time-series regression are in accord with the panel regression. Only fewer than 10% of the firms in China has reported a θ within the hypothesized range. In the US, I reproduce Christie's result in the panel regression with a reported $\theta = -0.3$. The mean and median θ for US firm-by-firm time-series regression also have the same sign as the panel θ. Approximately the middle 50% of the US firm θ

fall into the range of $-1 < \theta < 0$. By contrast, Christie's result on 379 US firms over 66 quarters from July 1962, where almost all firm-by-firm time-series θ are between -1 and 0. The R^2 for China and US panel regressions are 1.54% and 3.59% respectively. The R^2's are low in both countries but the model has more explanatory power for US stocks. Here, both levered and unlevered assets account for the value θ. To better test the hypothesis that the elasticity of equity volatility is decreasing in leverage, we bring in equation (16) in the next section.

6 Elasticity as a Function of Leverage

In regression (16), the γ_0 captures effect of stocks returns on volatility for unlevered assets, while γ_1 captures leverage effect. The effect of stock returns on volatility for the unlevered assets could be positive, if firms dynamically increase asset volatility after good stock price performance, for example, by making investments in higher volatility projects, as leverage and prospective bankruptcy costs fall. The result of this regression model is reported in Table 4.

Contrary to my hypothesis, in China, both γ_0 and γ_1 are positive and γ_1 is even greater than γ_0, indicating that in the Chinese A-share market, leverage actually contributes to the positive relation between equity returns and volatility as shown in section 4. Running the regression firm-by-firm, fewer than half of the firms exhibit a negative γ_1. For US firms, it is surprising that the "leverage effect" shown in regression 15 is actually not a leverage effect. The estimate of the coefficient γ_1 for the US panel regression is nearly 0. The mean and median coefficient estimates for individual firms are also very close to 0. It is also noteworthy that Leverage Ratio 2, $\frac{D_{it-1}}{V_{it-1}}$ is naturally bounded between 0 and 1. Therefore, $\gamma_1 \times \frac{D_{it-1}}{V_{it-1}}$ barely explains any variation in stock return volatility.

7 Asymmetry in "Leverage Effect"

Figlewski and Wang (2000) state that though theoretically the relation between stock return volatility and financial leverage should be symmetrical in both up and down market, evidence from

US data over the period 1991 to 1995 suggests that the “leverage effect” is a ”down market” phenomenon. To test whether this holds true in my more recent sample period as well as whether the “down market” phenomenon also appears in the Chinese stock market, I, follow Figlewski and Wang (2000), add an additional variable to regression 15 as follows:

$$\ln\left(\frac{\hat{\sigma}_{it+1}}{\hat{\sigma}_{it-1}}\right) = \alpha + \theta_1[\ln(R_{it})] + \theta_2[\ln(R_{it})] \times I + u_{it+1} \tag{17}$$

where $I = 1$ if R_{it} is less than 1 and 0 if otherwise. In the updated regression model, θ_1 measures the “leverage effect” in an up market and $\theta_1 + \theta_2$ measures the “leverage effect” in a down market. The regression results are reported in Table 5. After adding the additional variable, R^2’s for both China and US increase, indicating the updated model has better explanatory power. In China, θ_1 is positive and no “leverage effect” is detected in the up market. But, θ_1 + θ_2 = 0.49 + (-0.61)=-0.12 is negative. In another word, “leverage effect” appears in the down market for China. Meanwhile, in the US, although “leverage effect” appears in both up and down markets, it is more significant in the down market with $\theta_1 + \theta_2 = -0.40$.

8 Confounding Effects

The current regression results are puzzling. In China, the so-called “leverage effect” appears only in the down market. Even in the US where Christie’s result can be replicated with a more recent and larger sample, when I further break down elasticity as a function of leverage, it turns out that the negative relation between stock return and volatility is not actually associated by financial leverage. To investigate this further, I examine the dynamics of trading volume and corporate investment and debt issuance around stock returns.

First, I regress the change of the natural log of stock trading volume on the natural log of the stock return both without and with a dummy variable I for the down market:

$$\ln\left(\frac{tv_{it+1}}{tv_{it-1}}\right) = \alpha + \theta[\ln(R_{it})] + u_{it+1} \tag{18}$$

$$\ln\left(\frac{tv_{it+1}}{tv_{it-1}}\right) = \alpha + \theta_1[\ln(R_{it})] + \theta_2[\ln(R_{it})] \times I + u_{it+1} \tag{19}$$

Table 6 shows that in both China and the US, higher stock return is associated with higher trading volume. The estimate of the coefficient θ for the Chinese market is 0.32, larger than the US θ with the value of 0.24. In China, a positive stock return results in higher trading volume which may drive up the volatility and offset the "leverage effect". Table 7 further illustrates that in China, $\theta_1 + \theta_2 = 0.46 + (-0.33) = 0.13$, indicating the down market has a smaller impact on trading volume. While in the US, $\theta_1 + \theta_2 = 0.91 + (-1.14) = -0.23$, shows that a negative stock return results in higher trading volume that may explain why a "leverage effect" is more a down-market phenomenon in the US as shown in Table 5.

Next, I examine the effect of stock returns on subsequent corporate investment, defined as the change of the natural log of firm's book value of asset on the natural log of the stock return both without and with a dummy variable I for the down market:

$$\ln\left(\frac{asset_{it+1}}{asset_{it-1}}\right) = \alpha + \theta[\ln(R_{it})] + u_{it+1} \tag{20}$$

$$\ln\left(\frac{asset_{it+1}}{asset_{it-1}}\right) = \alpha + \theta_1[\ln(R_{it})] + \theta_2[\ln(R_{it})] \times I + u_{it+1} \tag{21}$$

The results in Tables 8 and 9 indicate a positive relation between stock price performance and subsequent corporate investment, which does not exhibit any asymmetry. These systematic changes in the composition of firm assets could cause changes in asset volatility that obscure the leverage effect.

Lastly, I regress the change in company debt on the natural log of the stock return both without and with a dummy variable I for the down market:

$$\frac{D_{it+1} - D_{it-1}}{V_{it-1}} = \alpha + \theta[\ln(R_{it})] + u_{it+1} \tag{22}$$

$$\frac{D_{it+1} - D_{it-1}}{V_{it-1}} = \alpha + \theta_1[\ln(R_{it})] + \theta_2[\ln(R_{it})] \times I + u_{it+1} \tag{23}$$

The results in Table 10 and 11 suggest that firms in China issue new debt in response to positive stock returns. Such a dynamic rebalancing of firm capital structure would mute the leverage effect implied by the static model underlying my hypotheses. In the US, the relation between stock return and subsequent debt issuance is very weak, consistent with the stronger evidence of a leverage effect in US stock return volatility.

9 Conclusion

The leverage effect refers to a negative relation between stock returns and stock return volatility. For both a riskless firm and a risky firm in a Black-Scholes-Merton model, I show that the elasticity of stock return volatility with respect to the stock price depends on leverage and should be negative and increasing when the leverage ratio goes down. My objective in this paper is to compare the leverage effects in the Chinese and US stock markets.

I first regress stock volatility on leverage and find that the so-called leverage effect appears in the US stock market but not in the Chinese stock market. However, this "naive" model does not have much explanatory power because it does not control for cross-sectional variation in asset volatility.

I then follow Christie (1982), and analyze the elasticity θ of stock return volatility with respect to stock returns. Hypothetically, θ must lie in the range between -1 and 0 if leverage effects hold. The panel regression estimate of the elasticity θ for the China sample is 0.22 and the coefficient estimates in the firm-by-firm time-series regressions averages about 0.27. Meanwhile, the corresponding numbers for the US sample are -0.30 and -0.48, respectively. The results suggest that the leverage effect is present in the US market but not in the Chinese market. Using an enhanced regression equation, which allows for differential volatility response to positive returns and negative returns, I find that there is asymmetry in the leverage effect. In China, the leverage effect is present in down markets and in the US, the leverage effect is more pronounced in down markets. I also extend Christie's model to allow the elasticity estimate to be a function of the firm leverage ratio and it turns out that even in the US, what is believed to be a "leverage effect" is not actually associated with leverage.

Finally, to further investigate these puzzling results, I examine the dynamics of trading volume, corporate investment and debt issuance around stock returns. I find that in China, dynamic trading volume, corporate investment and debt issuance all dampen the "leverage effect". On the other hand, dynamic trading volume and debt issuance make the "leverage effect" more pronounced for the US stock market, especially in the down market.

In conclusion, leverage effects in stock returns appear to be confounded by dynamics in trading volume and corporate decision-making.

Table 1: Summary Statistics

All variables are measured at quarterly frequency over the period 2001 Q4 to 2019 Q4. Leverage Ratio 1 (LR 1) is defined as (Market Value of Equity + Long-term Debt + Short-term Debt)/Market Value of Equity. Leverage Ratio 2 (LR 2) is defined as (Long-term Debt + Short-term Debt)/(Market Value of Equity + Long-term Debt + Short-term Debt). Volatility is the annualized daily stock return volatility over the quarter. Return is the annualized cumulative daily return over the quarter. Trading volume is the quarterly trading volume calculated by summing the daily trading volume within the quarter. Asset is the firm's quarterly book value of asset. Debt issuance is the difference of book value of debt between Q_n and $Q_n + 2$. For Asset and Debt Issuance variables, the numbers are in millions of the local currency.

	LR 1		LR 2		Volatility		Return		Trading Volume		Asset		Debt Issuance	
	China	US	China	US	China	US	China	US	China (RMB)	US (USD)	China (RMB)	US (USD)	China (RMB)	US (USD)
Mean	1.21	2.20	0.14	0.31	43.53	48.15	4.15	4.13	565.89	870.26	11572.41	8384.61	176.05	143.08
Std.Dev.	0.32	3.51	0.15	0.24	16.71	32.18	1.10	1.21	1287.27	3633.96	63921.93	35639.98	2360.44	1493.33
Min	1.00	1.00	0.00	0.00	14.54	10.92	0.65	0.00	0.01	0.01	0.05	0.01	-88775.00	-34034.00
1stPercentile	1.00	1.01	0.00	0.01	14.54	10.92	2.28	1.67	11.01	0.87	208.31	7.64	-2540.02	-1878.37
5thPercentile	1.00	1.03	0.00	0.03	21.08	16.22	2.81	2.56	28.45	4.00	509.01	20.49	-560.82	-321.02
10thPercentile	1.00	1.05	0.00	0.05	24.86	19.47	3.08	2.99	47.25	9.87	698.79	41.46	-247.39	-109.50
25thPercentile	1.01	1.14	0.01	0.12	31.67	26.85	3.48	3.58	111.03	44.50	1201.00	165.33	-49.45	-10.85
50thPercentile	1.09	1.35	0.08	0.26	40.67	39.45	3.94	4.05	266.92	183.09	2578.82	857.88	9.78	1.60
75thPercentile	1.26	1.84	0.21	0.46	52.40	58.85	4.58	4.55	604.68	633.83	6279.30	4148.15	138.20	50.06
90thPercentile	1.57	3.01	0.37	0.67	66.65	85.80	5.45	5.18	1236.48	1898.94	17144.82	16773.00	539.18	352.55
95thPercentile	1.87	5.07	0.47	0.80	75.98	111.11	6.14	5.76	1912.21	3459.42	34315.10	34809.25	1195.01	932.00
99thPercentile	2.84	29.68	0.65	0.97	99.03	196.01	7.93	7.90	4592.62	10976.10	161875.60	135923.40	5637.52	4452.42
Max	2.84	29.68	0.65	1.00	99.03	196.01	29.53	73.23	110970	519934.70	2701213.00	1199993.00	166811.50	82060.00

Table 2: Direct Regressions of Volatility on Leverage

Estimation results for the following regression:

$$\ln \hat{\sigma}_{it+1} = \alpha + \beta \ln \frac{V_{it}}{E_{it}} + \varepsilon_{it+1} \,.$$

Here, $\hat{\sigma}$ is the annualized daily stock return volatility over the quarter. V is the market value of equity + the book value of debt. E is the market value of equity.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the leverage coefficients and their t-statistics from firm-by-firm time-series regressions.

	China		US	
A. Panel regressions				
Constant (α)	0.96		0.86	
	(746.85)		(413.77)	
$\ln \frac{V_{it}}{E_{it}} (\beta)$	-0.15		0.06	
	(-31.65)		(23.26)	
R^2	0.70		0.46	
No. Obs.	141,140		116,593	
B. Firm-by-firm time-series regressions				
	β	$t(\beta)$	β	$t(\beta)$
Mean	-11.13	-0.46	-0.10	1.46
Std. Dev	385.20	1.75	37.08	2.83
1st Percentile	-127.67	-4.76	-12.09	-4.14
5th Percentile	-15.03	-3.21	-2.95	-2.18
10th Percentile	-6.55	-2.55	-1.35	-1.43
25th Percentile	-1.65	-1.50	-0.12	-0.23
50th Percentile	-0.33	-0.44	0.42	1.11
75th Percentile	0.49	0.61	1.04	2.89
90th Percentile	2.75	1.64	2.28	4.79
95th Percentile	8.65	2.30	4.02	6.25
99th Percentile	84.42	3.53	18.35	8.96

Table 3: Elasticity of Volatility with Respect to Stock Return

Estimation results for the following regression:

$$\ln\left(\frac{\hat{\sigma}_{it+1}}{\hat{\sigma}_{it-1}}\right) = \alpha + \theta[\ln(R_{it})] + u_{it+1} \ .$$

Here, $\hat{\sigma}$ is the annualized daily stock return volatility over the quarter. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the return coefficients and their t-statistics from firm-by-firm time-series regressions.

	China		US	
A. Panel regressions				
Constant (α)	-0.04		-0.01	
	(-35.24)		(-8.11)	
$\ln(R_{it})$ (θ)	0.22		-0.30	
	(46.31)		(-77.56)	
R^2	1.54		3.59	
No. Obs.	136,949		161,716	
B. Firm-by-firm time-series regressions				
	θ	$t(\theta)$	θ	$t(\theta)$
Mean	0.27	0.77	-0.48	-1.21
Std. Dev	0.55	1.13	9.18	2.34
1st Percentile	-1.16	-2.05	-4.21	-5.14
5th Percentile	-0.50	-1.13	-1.57	-3.81
10th Percentile	-0.24	-0.65	-1.17	-3.17
25th Percentile	0.03	0.08	-0.71	-2.15
50th Percentile	0.24	0.82	-0.36	-1.09
75th Percentile	0.49	1.48	-0.06	-0.17
90th Percentile	0.84	2.08	0.28	0.68
95th Percentile	1.11	2.52	0.62	1.14
99th Percentile	1.96	3.38	3.30	2.48

Table 4: Volatility-Stock Return Elasticity as a Function of Leverage

Estimation results for the following regression:

$$\ln\left(\frac{\hat{\sigma}_{it+1}}{\hat{\sigma}_{it-1}}\right) = \alpha + [\gamma_0 + \gamma_1(\frac{D_{it-1}}{V_{it-1}})][\ln R_{it}] + \gamma_2(\frac{D_{it-1}}{V_{it-1}}) + n_{it+1} \ .$$

Here, $\hat{\sigma}$ is the annualized daily stock return volatility over the quarter. D is the book value of debt. V is the market value of equity + the book value of debt. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the interaction coefficients and their t-statistics from firm-by-firm time-series regressions.

	China		US	
A. Panel regressions				
Constant (α)	-0.04		-0.01	
	(-23.64)		(-5.59)	
$\ln R_{it}$ (γ_0)	0.17		-0.30	
	(27.33)		(-63.43)	
$\frac{D_{it-1}}{V_{it-1}} \times \ln R_{it}$ (γ_1)	0.32		0.00	
	(10.04)		(3.64)	
$\frac{D_{it-1}}{V_{it-1}}$ (γ_2)	0.08		-0.00	
	(10.27)		(-4.62)	
R^2	1.78		3.46	
No .Obs.	133,446		112,870	
B. Firm-by-firm time-series regressions				
	γ_1	$t(\gamma_1)$	γ_1	$t(\gamma_1)$
Mean	72.53	0.19	-0.05	0.09
Std. Dev	3697.96	1.29	39.20	1.72
1st Percentile	-865.49	-2.48	-57.54	-2.88
5th Percentile	-66.53	-1.57	-11.37	-1.82
10th Percentile	-22.89	-1.18	-5.11	-1.38
25th Percentile	-22.89	-0.55	-1.00	-0.67
50th Percentile	0.61	0.14	0.01	0.07
75th Percentile	4.71	0.91	1.01	0.81
90th Percentile	24.91	1.73	4.84	1.53
95th Percentile	68.07	2.22	10.86	2.02
99th Percentile	550.28	3.05	70.84	3.12

Table 5: Asymmetry in "Leverage Effect"

Estimation results for the following regression:

$$\ln\left(\frac{\hat{\sigma}_{it+1}}{\hat{\sigma}_{it-1}}\right) = \alpha + \theta_1[\ln(R_{it})] + \theta_2[\ln(R_{it})] \times I + u_{it+1}\ .$$

Here, $\hat{\sigma}$ is the annualized daily stock return volatility over the quarter. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the return and down market return coefficients and their t-statistics from firm-by-firm time-series regressions.

	China				US			
A. Panel regressions								
Constant (α)	-0.10				-0.03			
	(-54.35)				(-21.65)			
$\ln R_{it}$ (θ_1)	0.49				-0.15			
	(60.93)				(-20.79)			
$[\ln(R_{it})] \times I(\theta_2)$	-0.61				-0.25			
	(-41.20)				(-23.34)			
R^2	2.75				3.90			
No .Obs.	136,949				161,716			
B. Firm-by-firm time-series regressions								
	θ_1	$t(\theta_1)$	θ_2	$t(\theta_2)$	θ_1	$t(\theta_1)$	θ_2	$t(\theta_2)$
Mean	0.54	1.00	-0.54	-0.65	-0.55	-0.02	0.66	-0.49
Std. Dev	2.10	4.95	2.68	4.46	14.39	15.01	37.00	13.18
1st Percentile	-3.41	-2.35	-7.34	-3.02	-15.50	-3.80	-12.78	-12.78
5th Percentile	-1.17	-1.08	-3.03	-2.26	-2.69	-2.42	-3.88	-3.88
10th Percentile	-0.50	-0.55	-2.00	-1.89	-1.67	-1.86	-2.43	-2.43
25th Percentile	0.14	0.23	-1.19	-1.28	-0.75	-1.02	-1.18	-1.18
50th Percentile	0.50	0.98	-0.61	-0.64	-0.14	-0.22	-0.37	-0.37
75th Percentile	0.88	1.71	0.09	0.08	0.35	0.54	0.37	0.37
90th Percentile	1.46	2.30	1.31	0.78	1.06	1.28	1.69	1.69
95th Percentile	2.01	2.67	2.63	1.25	1.06	1.79	3.52	3.52
99th Percentile	4.66	3.34	6.02	2.21	8.04	3.09	16.54	16.54

Table 6: Elasticity of Trading Volume with Respect to Stock Return

Estimation results for the following regression:

$$\ln\left(\frac{tv_{it+1}}{tv_{it-1}}\right) = \alpha + \theta[\ln(R_{it})] + u_{it+1}\ .$$

Here, tv is the quarterly trading volume calculated by summing the daily trading volume within the quarter. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the return and down market return coefficients and their t-statistics from firm-by-firm time-series regressions.

	China		US	
A. Panel regressions				
Constant (α)	0.08		0.05	
	(32.05)		(30.39)	
$\ln R_{it}$ (θ)	0.32		0.24	
	(31.83)		(40.07)	
R^2	0.74		0.92	
No. Obs.	137,141		172,225	
B. Firm-by-firm time-series regressions				
	θ	$t(\theta)$	θ	$t(\theta)$
Mean	0.26	0.62	0.31	0.37
Std. Dev	1.69	2.11	15.76	6.36
1st Percentile	-4.63	-2.10	-6.55	-3.89
5th Percentile	-1.44	-1.22	-1.66	-2.47
10th Percentile	-0.70	-0.80	-0.98	-1.81
25th Percentile	-0.09	-0.13	-0.37	-0.79
50th Percentile	0.33	0.60	0.10	0.22
75th Percentile	0.72	1.32	0.67	1.30
90th Percentile	1.26	1.93	1.35	2.44
95th Percentile	1.78	2.39	2.03	3.13
99th Percentile	3.74	3.32	9.97	4.91

Table 7: Asymmetry in Trading Volume-Stock Return Elasticity

Estimation results for the following regression:

$$\ln\left(\frac{tv_{it+1}}{tv_{it-1}}\right) = \alpha + \theta_1[\ln(R_{it})] + \theta_2[\ln(R_{it})] \times I + u_{it+1} \, .$$

Here, tv is the quarterly trading volume calculated by summing the daily trading volume within the quarter. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the return and down market return coefficients and their t-statistics from firm-by-firm time-series regressions.

	China				US			
A. Panel regressions								
Constant (α)	0.05				-0.05			
	(13.99)				(-24.22)			
$\ln R_{it}$ (θ_1)	0.46				0.91			
	(28.83)				(80.54)			
$[\ln(R_{it})] \times I(\theta_2)$	-0.33				-1.14			
	(-10.98)				(-69.57)			
R^2	0.83				3.63			
No. Obs.	137,141				172,225			
B. Firm-by-firm time-series regressions								
	θ_1	$t(\theta_1)$	θ_2	$t(\theta_2)$	θ_1	$t(\theta_1)$	θ_2	$t(\theta_2)$
Mean	0.24	0.53	-0.13	-0.24	1.16	0.65	-12449.25	-0.56
Std. Dev	11.73	1.09	14.84	1.13	28.12	2.70	631917.90	3.30
1st Percentile	-8.39	-2.05	-16.84	-3.01	-17.03	-3.09	-36.39	-4.05
5th Percentile	-2.58	-1.13	-5.87	-1.95	-3.35	-1.75	-6.51	-2.77
10th Percentile	-1.30	-0.80	-3.74	-1.57	-1.54	-1.25	-4.00	-2.21
25th Percentile	-0.20	-0.18	-1.67	-0.85	-0.37	-0.39	-2.08	-1.40
50th Percentile	0.48	0.51	-0.38	-0.20	0.54	0.60	-0.74	-0.53
75th Percentile	1.16	1.20	0.91	0.45	1.54	1.63	0.43	0.29
90th Percentile	2.09	1.89	3.10	1.06	2.78	2.72	2.29	1.01
95th Percentile	3.42	2.33	5.61	1.39	4.42	3.42	4.61	1.44
99th Percentile	9.03	3.19	17.42	2.23	31.34	5.21	28.66	2.51

Table 8: Investment vs. Stock Return

Estimation results for the following regression:

$$\ln\left(\frac{asset_{it+1}}{asset_{it-1}}\right) = \alpha + \theta[\ln(R_{it})] + u_{it+1}.$$

Here, $asset$ is the book value of firm asset. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the return and down market return coefficients and their t-statistics from firm-by-firm time-series regressions.

	China		US	
A. Panel regressions				
Constant (α)	0.06		0.04	
	(102.04)		(44.55)	
$\ln R_{it}$ (θ)	0.06		0.12	
	(21.80)		(64.05)	
R^2	0.34		1.49	
No. Obs.	139,058		131,562	
B. Firm-by-firm time-series regressions				
	θ	$t(\theta)$	θ	$t(\theta)$
Mean	0.03	0.27	-0.35	0.79
Std. Dev	0.17	1.16	32.08	1.52
1st Percentile	-0.40	-2.47	-1.90	-2.53
5th Percentile	-0.18	-1.50	-0.29	-1.28
10th Percentile	-0.11	-1.10	-0.13	-0.79
25th Percentile	-0.04	-0.45	-0.01	-0.08
50th Percentile	0.02	0.23	0.07	0.77
75th Percentile	0.08	0.96	0.19	1.64
90th Percentile	0.18	1.71	0.34	2.53
95th Percentile	0.28	2.19	0.50	3.13
99th Percentile	0.65	3.33	1.25	4.33

Table 9: Asymmetry in Investment vs. Stock Return

Estimation results for the following regression:

$$\ln\left(\frac{asset_{it+1}}{asset_{it-1}}\right) = \alpha + \theta_1[\ln(R_{it})] + \theta_2[\ln(R_{it})] \times I + u_{it+1}\ .$$

Here, $asset$ is the book value of firm asset. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the return and down market return coefficients and their t-statistics from firm-by-firm time-series regressions.

	China				US			
A. Panel regressions								
Constant (α)	0.01				0.04			
	(66.64)				(46.13)			
$\ln R_{it}$ (θ_1)	0.06				0.12			
	(14.26)				(24.81)			
$[\ln(R_{it})] \times I(\theta_2)$	-0.01				-0.01			
	(-1.26)				(-1.12)			
R^2	0.34				1.49			
No. Obs.	139,058				131,562			
B. Firm-by-firm time-series regressions								
	θ_1	$t(\theta_1)$	θ_2	$t(\theta_2)$	θ_1	$t(\theta_1)$	θ_2	$t(\theta_2)$
Mean	0.02	0.15	0.02	0.02	0.02	0.36	-2.51	-4.11
Std. Dev	0.55	1.29	0.74	1.22	32.48	1.83	105.97	136.37
1st Percentile	-1.00	-2.71	-1.94	-3.26	-4.95	-2.71	-7.58	-3.61
5th Percentile	-0.44	-1.69	-0.90	-2.08	-0.95	-1.63	-1.65	-2.11
10th Percentile	-0.27	-1.26	-0.54	-1.54	-0.40	-1.16	-0.89	-1.49
25th Percentile	-0.11	-0.66	-0.18	-0.68	-0.11	-0.55	-0.26	-0.66
50th Percentile	0.00	0.02	0.03	0.11	0.05	0.26	0.04	0.15
75th Percentile	0.13	0.85	0.24	0.79	0.24	1.12	0.31	0.91
90th Percentile	0.33	1.76	0.53	1.43	0.66	2.04	0.80	1.73
95th Percentile	0.54	2.43	0.84	1.86	1.10	2.66	1.58	2.20
99th Percentile	1.29	3.92	1.99	2.70	4.08	4.05	6.36	3.45

Table 10: Debt Issuance vs. Stock Return

Estimation results for the following regression:

$$\frac{D_{it+1} - D_{it-1}}{V_{it-1}} = \alpha + \theta[\ln(R_{it})] + u_{it+1}.$$

Here, D is the book value of debt. V is the market value of equity + book value of debt. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the return and down market return coefficients and their t-statistics from firm-by-firm time-series regressions.

	China		US	
A. Panel regressions				
Constant (α)	0.01		0.04	
	(7.03)		(1.99)	
$\ln R_{it}$ (θ)	0.04		0.20	
	(5.37)		(2.32)	
R^2	0.02		0.00	
No. Obs.	119,051		113,139	
B. Firm-by-firm time-series regressions				
	θ	$t(\theta)$	θ	$t(\theta)$
Mean	0.04	-0.20	0.19	0.41
Std. Dev	2.60	2.00	7.14	6.65
1st Percentile	-0.79	-6.78	-2.19	-3.27
5th Percentile	-0.34	-3.30	-0.35	-1.81
10th Percentile	-0.19	-2.25	-0.16	-1.24
25th Percentile	-0.04	-0.89	-0.03	-0.49
50th Percentile	0.00	-0.04	0.01	0.28
75th Percentile	0.02	0.67	0.08	1.06
90th Percentile	0.08	1.48	0.25	1.87
95th Percentile	0.17	2.22	0.55	2.42
99th Percentile	0.72	5.20	5.32	3.89

Table 11: Asymmetry in Debt Issuance vs. Stock Return

Estimation results for the following regression:

$$\frac{D_{it+1} - D_{it-1}}{V_{it-1}} = \alpha + \theta_1[\ln(R_{it})] + \theta_2[\ln(R_{it})] \times I + u_{it+1} .$$

Here, D is the book value of debt. V is the market value of equity + book value of debt. R is the annualized cumulative daily return over the quarter.

In this table, Panel A contains panel estimation results. R^2's are in percent. Panel B contains summary statistics for the return and down market return coefficients and their t-statistics from firm-by-firm time-series regressions.

	China				US			
A. Panel regressions								
Constant (α)	0.01				0.11			
	(3.13)				(3.52)			
$\ln R_{it}$ (θ_1)	0.07				-0.22			
	(5.34)				(-1.33)			
$[\ln(R_{it})] \times I(\theta_2)$	-0.06				0.73			
	(-2.4)				(3.03)			
R^2	0.03				0.00			
No. Obs	119,051				113,139			
B. Firm-by-firm time-series regressions								
	θ_1	$t(\theta_1)$	θ_2	$t(\theta_2)$	θ_1	$t(\theta_1)$	θ_2	$t(\theta_2)$
Mean	0.01	21.66	0.01	-3.94	0.12	-0.04	0.42	0.21
Std. Dev	3.05	1228.69	3.75	228.21	15.08	3.40	21.87	2.74
1st Percentile	-1.49	-10.77	-2.16	-4.09	-7.55	-5.16	-13.72	-4.00
5th Percentile	-0.54	-4.13	-0.63	-1.99	-1.21	-2.58	-1.60	-2.17
10th Percentile	-0.32	-2.43	-0.28	-1.44	-0.50	-1.74	-0.62	-1.60
25th Percentile	-0.08	-1.08	-0.08	-0.70	-0.12	-0.84	-0.15	-0.70
50th Percentile	-0.01	-0.16	0.01	0.12	0.00	0.02	0.02	0.16
75th Percentile	0.05	0.77	0.12	0.96	0.13	0.94	0.23	0.95
90th Percentile	0.16	1.70	0.44	1.77	0.47	1.89	0.84	1.84
95th Percentile	0.34	2.65	0.78	2.54	1.17	2.65	1.73	2.55
99th Percentile	1.16	6.88	2.57	4.94	12.96	4.94	11.38	4.72

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