Replicating Lemmon, Roberts, and Zender (2008)

Yongseok Kim

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1 Introduction

In this paper, I replicate Lemmon, Roberts, and Zender (2008, Journal of Finance)'s results. In short, results are replicated well. However, it is hard to exactly replicate statistics on Industry median leverage. Moreover, I fail to replicate column (g) of Table 6, which estimates system GMM (Blundell and Bond, 1998).

2 Data and Variables

- Although LRZ define **Firm Size** as log(book assets) where assets are deflated by the GDP deflator in the appendix, they never use this variable. Instead, they use **Log(Sales)** which does not appear in the appendix**.** I use log(sale) where sales are deflated by the GDP deflator.
- LRZ do not clarify a definition of **Cash Flow Volatility**. I use 10 years standard deviation of historical operating income (**oibdp**), requiring at least 3 years of data.
- In the appendix, LRZ define **Net equity Issuance** as

$$(csho_t - csho_{t-1} \times \frac{ajex_{t-1}}{ajex_t}) \times (prcc\_f_t + prcc\_f_{t-1} \times \frac{ajex_t}{ajex_{t-1}}) \times \frac{1}{at_{t-1}}.$$

  I think this is a typo. Instead, I use

$$(csho_t - csho_{t-1} \times \frac{ajex_{t-1}}{ajex_t}) \times \frac{1}{2} \times (prcc\_f_t + prcc\_f_{t-1} \times \frac{ajex_t}{ajex_{t-1}}) \times \frac{1}{at_{t-1}}.$$

- I define **Dividend payer** as

$$I\{dvc_t > 0\}$$

  and **Intangible assets** as

$$\frac{intan_t}{at_t}$$

3 Results

- Table 1: Summary statistics are replicated well, except a standard deviation of **Industry median lev.**
- Figure 1 and 2: Main figures are replicated well.

- Table 2: The main table is replicated well. Exceptions are **Cash flow vol.** and **Industry median lev.**
- Table 3: The table is replicated well.
- Table 4: LRZ do not specify how they calculate standard errors of long-run impact terms. By the Delta method, I derive

$$F(\theta) = \begin{bmatrix} \iota' & & & \\ & \iota' & & \\ & & \ddots & \\ & & & \iota' \end{bmatrix}$$

where

$$\iota = [1, \cdots, 1]'$$

and

$$\begin{aligned} f(\hat{\theta}) - f(\theta) &\approx F(\theta)(f(\hat{\theta}) - f(\theta)) \\ &=_d F(\theta)\mathbb{N}(0, V). \end{aligned}$$

Hence

$$\begin{aligned} \text{avar}(f(\hat{\theta})) &= F(\theta)VF(\theta)' \\ &= \begin{bmatrix} \iota' V_1 \iota & & & \\ & \ddots & & \\ & & \iota' V_k \iota \end{bmatrix} \end{aligned}$$

where V_j is $l \times l$ submatrix of variable j and l is a number of lags.

- Table 5: It is hard to get exactly same numbers.
- Figure 3: This figure is replicated well.
- Table 6: It is hard to replicate column (g).
  - **Half-life**: Let

$$\text{avar}(\lambda) = V.$$

Define

$$f(\lambda) = \frac{\ln 0.5}{\ln(1-\lambda)},$$

$$\begin{aligned} F(\lambda) &= \frac{\partial}{\partial \lambda} f(\lambda) \\ &= \frac{\ln 0.5}{\ln(1-\lambda)^2} \frac{1}{1-\lambda}. \end{aligned}$$

By the Delta method, we obtain

$$\begin{aligned} \text{avar}(f(\hat{\lambda})) &= F(\hat{\lambda})VF(\hat{\lambda}) \\ &= \Big[\frac{\ln 0.5}{\ln(1-\lambda)^2} \frac{1}{1-\lambda}\Big]^2 V. \end{aligned}$$

– β: Let

$$\text{avar}(-\lambda, \lambda\beta_1, \cdots, \lambda\beta_j) = V.$$

Define

$$\begin{aligned} f(-\lambda, \lambda\beta_1, \cdots, \lambda\beta_j) &= [-\frac{\lambda\beta_1}{-\lambda}, \cdots, -\frac{\lambda\beta_j}{-\lambda}]' \\ &= [\beta_1, \cdots, \beta_j]', \end{aligned}$$

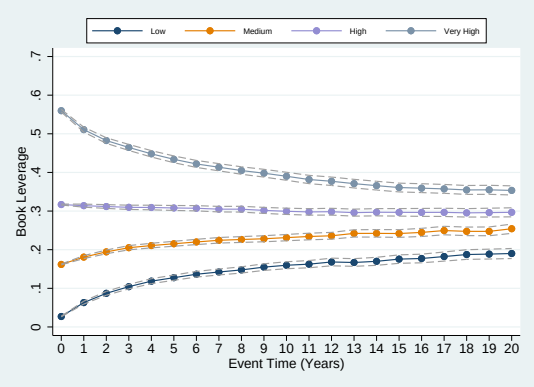
$$\begin{aligned} F(-\lambda, \lambda\beta_1, \cdots, \lambda\beta_j) &= \frac{\partial}{\partial\theta'} f(\lambda, \lambda\beta_1, \cdots, \lambda\beta_j) \\ &= \begin{bmatrix} \beta_1/\lambda & 1/\lambda & 0 & \cdots & 0 \\ \beta_2/\lambda & 0 & 1/\lambda & & \\ \vdots & \vdots & & \ddots & \\ \beta_j/\lambda & 0 & & & 1/\lambda \end{bmatrix}. \end{aligned}$$

By the Delta method, we obtain

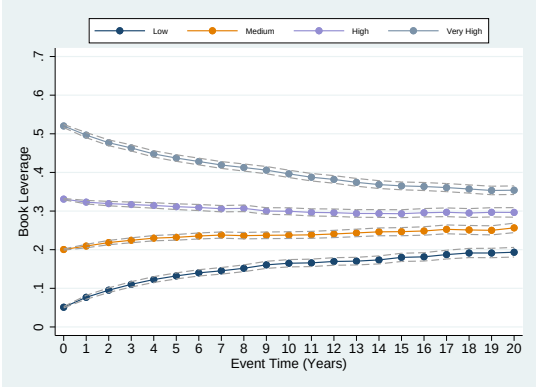
$$\text{avar}(\beta) = \frac{1}{\lambda^2}[\beta, I_j] V [\beta, I_j]'.$$

Table 1: Summary Statistics

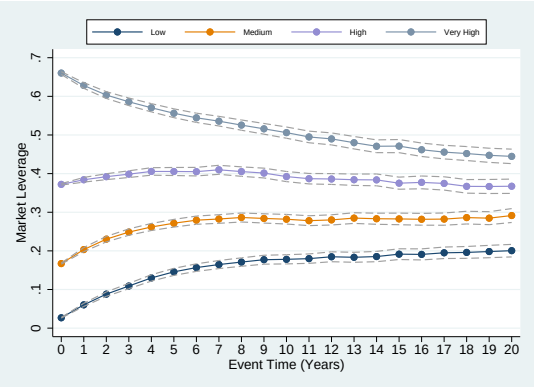
	All Firms		Survivors	
	Mean [Median]	(SD)	Mean [Median]	(SD)
Book leverage	0.26 [0.24]	(0.22)	0.27 [0.26]	(0.19)
Market leverage	0.30 [0.24]	(0.27)	0.32 [0.29]	(0.25)
Log(Sales)	4.72 [4.84]	(2.50)	5.75 [5.90]	(2.30)
Market-to-book	1.59 [1.00]	(1.84)	1.25 [0.89]	(1.25)
Profitability	0.05 [0.11]	(0.26)	0.11 [0.13]	(0.15)
Tangibility	0.32 [0.26]	(0.26)	0.38 [0.33]	(0.25)
Cash flow vol.	0.09 [0.05]	(0.14)	0.06 [0.04]	(0.08)
Median industry book leverage	0.23 [0.25]	(0.08)	0.25 [0.25]	(0.06)
Dividend payer	0.42 [0.00]	(0.49)	0.62 [1.00]	(0.49)
Intangible assets	0.05 [0.00]	(0.10)	0.04 [0.00]	(0.08)
Obs.	271,139		106,282	



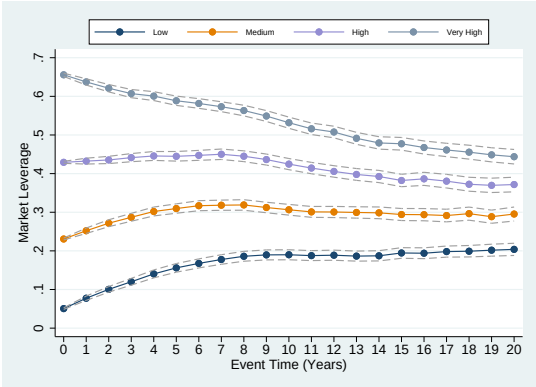
(a) Book Leverage Portfolio



(b) Book Leverage Portfolio (Survivors)

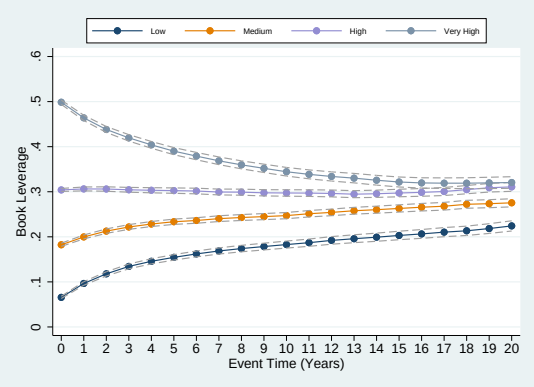


(c) Market Leverage Portfolios

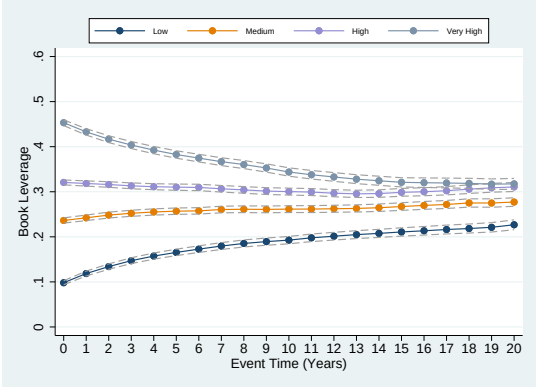


(d) Market Leverage Portfolios (Survivors)

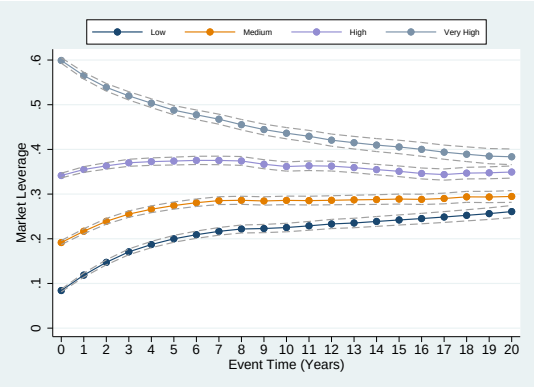
Figure 1: Average leverage of actual leverage portfolios in event time



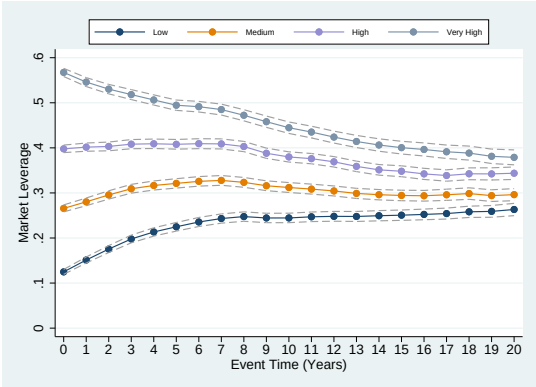
(a) Book Leverage Portfolio



(b) Book Leverage Portfolio (Survivors)



(c) Market Leverage Portfolios



(d) Market Leverage Portfolios (Survivors)

Figure 2: Average leverage of unexpected leverage portfolios in event time

Table 2: The Effect of Initial Leverage on Future Leverage

(a) All Firms

Variable	Book Leverage			Market Leverage		
Initial leverage	0.08	0.07	0.06	0.12	0.10	0.09
	(49.16)	(45.25)	(41.86)	(63.48)	(52.04)	(49.93)
Log(Sales)		0.02	0.03		0.02	0.04
		(12.48)	(17.39)		(12.59)	(22.43)
Market-to-book		−0.02	−0.02		−0.06	−0.06
		(−22.13)	(−18.69)		(−45.14)	(−43.84)
Profitability		−0.03	−0.03		−0.05	−0.05
		(−24.01)	(−25.64)		(−33.09)	(−34.91)
Tangibility		0.04	0.04		0.04	0.04
		(29.25)	(28.69)		(23.26)	(24.45)
Industry median lev.			0.02			0.02
			(17.21)			(15.12)
Cash flow vol.			−0.01			−0.01
			(−5.44)			(−5.22)
Dividend payer			−0.03			−0.05
			(−23.42)			(−33.18)
Year fixed effects	No	Yes	Yes	No	Yes	Yes
Adj. R^2	0.15	0.22	0.25	0.22	0.34	0.37
Obs.	135,868	135,868	135,868	136,289	136,289	136,289

Table 2: Continued

(b) Survivors

Variable	Book Leverage			Market Leverage		
Initial leverage	0.08	0.07	0.06	0.11	0.08	0.08
	(32.35)	(26.87)	(25.47)	(36.68)	(29.41)	(28.11)
Log(Sales)		0.02	0.03		0.03	0.04
		(9.45)	(12.52)		(10.79)	(15.82)
Market-to-book		−0.02	−0.02		−0.07	−0.07
		(−11.01)	(−10.06)		(−24.79)	(−24.55)
Profitability		−0.05	−0.05		−0.09	−0.09
		(−16.46)	(−17.28)		(−20.63)	(−22.23)
Tangibility		0.04	0.04		0.04	0.04
		(18.61)	(18.96)		(17.46)	(18.52)
Industry median lev.			0.02			0.02
			(8.15)			(7.45)
Cash flow vol.			−0.01			−0.02
			(−3.73)			(−4.79)
Dividend payer			−0.03			−0.05
			(−15.53)			(−20.98)
Year fixed effects	No	Yes	Yes	No	Yes	Yes
Adj. R^2	0.17	0.25	0.28	0.19	0.37	0.39
Obs.	75,001	75,001	75,001	74,889	74,889	74,889

Table 3: Variance Decomposition

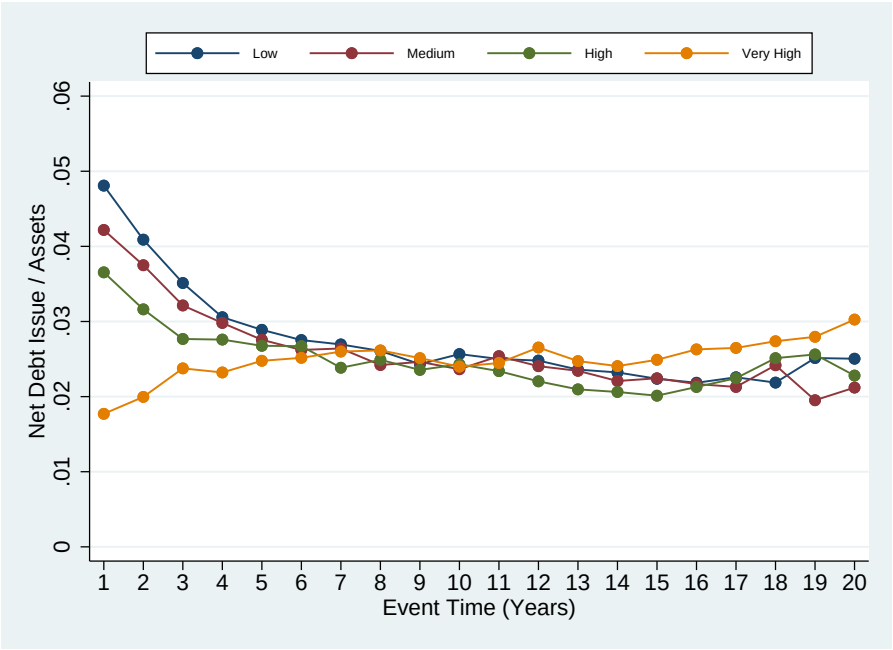
	Book Leverage							Market Leverage						
Variable	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Firm FE	1.00	.	0.99	.	0.89	.	0.87	1.00	.	0.95	.	0.92	.	0.88
Year FE	.	1.00	0.01	0.02	0.01	0.03	0.02	.	1.00	0.05	0.04	0.02	0.03	0.03
Log(Sales)	.	.	.	0.03	0.01	0.03	0.00	.	.	.	0.04	0.01	0.03	0.00
Market-to-book	.	.	.	0.35	0.08	0.12	0.03	.	.	.	0.20	0.04	0.08	0.02
Profitability	.	.	.	0.02	0.01	0.01	0.00	.	.	.	0.03	0.01	0.02	0.00
Tangibility	.	.	.	0.06	0.00	0.05	0.00	.	.	.	0.06	0.00	0.04	0.00
Industry med lev	.	.	.	.	.	0.00	0.00	.	.	.	.	.	0.00	0.00
Cash flow vol	.	.	.	.	.	0.34	0.06	.	.	.	.	.	0.31	0.07
Dividend payer	.	.	.	.	.	0.01	0.00	.	.	.	.	.	0.02	0.00
Industry FE	.	.	.	0.51	.	0.41	.	.	.	.	0.65	.	0.46	.
Adj. Rsq	0.59	0.01	0.59	0.19	0.68	0.21	0.69	0.60	0.05	0.64	0.23	0.68	0.27	0.70

Table 4: A Distributed Lag Model of Leverage

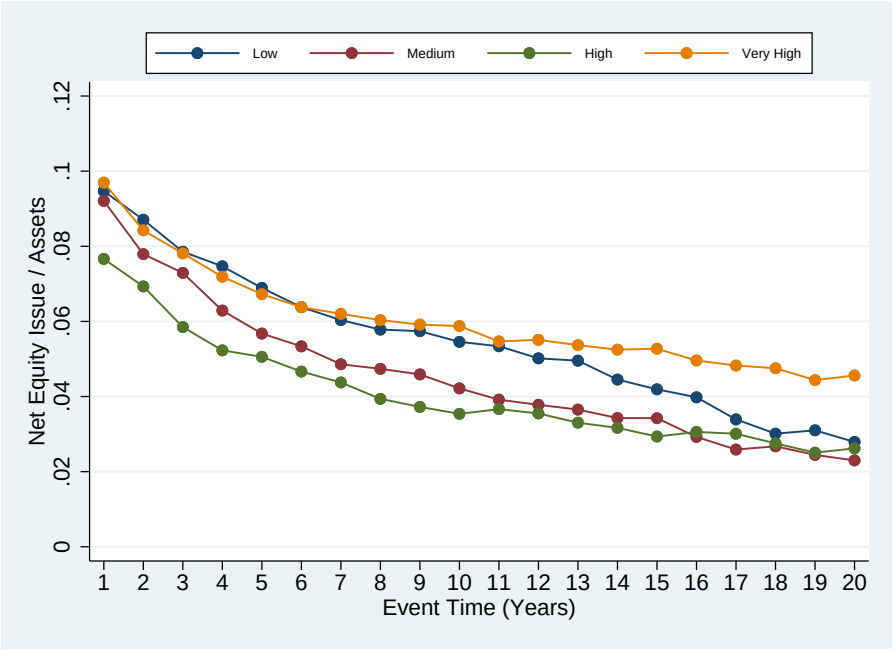
	Book Leverage		Market Leverage	
Variable	Short Run	Long Run	Short Run	Long Run
Initial leverage	0.04		0.06	
	(19.73)		(21.22)	
Log(Sales)	0.03	0.02	0.03	0.03
	(4.14)	(8.84)	(3.04)	(11.74)
Market-to-book	−0.01	−0.02	−0.04	−0.07
	(−5.95)	(−9.03)	(−19.54)	(−22.17)
Profitability	−0.02	−0.06	−0.04	−0.09
	(−11.12)	(−19.32)	(−16.87)	(−26.77)
Tangibility	0.04	0.04	0.05	0.04
	(11.84)	(16.62)	(12.06)	(16.65)
Industry median lev.	0.01	0.02	0.01	0.02
	(4.07)	(9.46)	(4.94)	(9.42)
Cash flow vol.	−0.01	−0.02	−0.03	−0.02
	(−3.60)	(−8.27)	(−6.82)	(−7.38)
Dividend payer	−0.03	−0.03	−0.05	−0.05
	(−15.71)	(−10.91)	(−21.14)	(−16.08)
Year fixed effects	Yes		Yes	
Adj. R^2	0.25		0.39	
Obs.	58,111		58,064	

Table 5: Parameter Sensitivities to Model Specification

	Book Leverage			Market Leverage		
Variable	Pooled OLS	Firm FE	% Change	Pooled OLS	Firm FE	% Change
Log(Sales)	0.013	0.015	16.282	0.020	0.015	−27.339
	(16.54)	(20.22)		(21.51)	(20.22)	
Market-to-book	−0.015	−0.002	−88.247	−0.050	−0.002	−96.374
	(−22.38)	(−5.37)		(−47.78)	(−5.37)	
Profitability	−0.165	−0.040	−75.848	−0.279	−0.040	−85.704
	(−26.22)	(−14.22)		(−36.68)	(−14.22)	
Tangibility	0.208	0.083	−60.132	0.210	0.083	−60.570
	(33.55)	(17.92)		(28.43)	(17.92)	
Industry median lev.	0.420	0.074	−82.455	0.533	0.074	−86.153
	(22.23)	(6.95)		(24.10)	(6.95)	
Cash flow vol.	−0.087	0.105	−221.589	−0.152	0.105	−169.114
	(−7.71)	(10.10)		(−11.62)	(10.10)	
Dividend payer	−0.087	0.000	−100.148	−0.121	0.000	−100.106
	(−28.67)	(0.09)		(−33.31)	(0.09)	
Year fixed effects	Yes	Yes		Yes	Yes	
Adj. R^2	0.160			0.263		
AR(1)		0.659			0.659	
Obs.	135,868	121,301		136,289	121,301	



(a) Net Debt Issuing Activity



(b) Net Equity Issuing Activity

Figure 3: Financing behavior of unexpected leverage portfolios in event time

Table 6: Speed of Adjustment

	Pooled OLS			Firm Fixed Effects		GMM	
Variable	(a)	(b)	(c)	(d)	(e)	(f)	(g)
SOA	0.11	0.12	0.14	0.34	0.36	0.20	0.15
	(48.28)	(47.27)	(46.91)	(60.97)	(60.15)	(35.19)	(14.58)
Initial leverage		0.22	0.18				
		(16.47)	(13.91)				
Log(Sales)			0.00		0.01		−0.07
			(2.03)		(4.87)		(−6.14)
Market-to-book			−0.01		−0.00		−0.02
			(−4.11)		(−2.67)		(−3.60)
Profitability			−0.25		−0.11		0.81
			(−8.22)		(−5.80)		(10.59)
Tangibility			0.14		0.11		−0.64
			(12.74)		(6.74)		(−8.18)
Industry median lev.			0.23		0.01		−0.81
			(5.54)		(0.27)		(−6.15)
Half-life	5.81	5.22	4.71	1.66	1.57	3.17	4.19
	(45.46)	(44.20)	(43.55)	(49.12)	(47.87)	(31.48)	(13.41)
Year fixed effects	No	No	Yes	No	Yes	No	Yes
R^2	0.047	0.050	0.064	0.230	0.240		
N	92,560	92,560	92,560	91,422	91,422	92,560	81,702