Firm Size and Leverage Relationship and Implications in a Low Interest Rate World

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What We Do

- Document that bigger firms (by sales) have lower coefficient of variation of sales and higher leverage ratios
- Develop a model of firm dynamics with default risk that can explain this pattern
- Application of the model: A lower risk-free rate implies a decline in the business startup rate and a rise in business concentration

Model Features

Why Larger Firms Have Lower Coefficient of Variation of Sales Growth

- Firm size is determined by the number of varieties it owns, K
- A variety may become extinct with some constant probability ϕ
- By LLN there is less uncertainty about the sales growth of firms that own more varieties

Model Features

Why Larger Firms Have Higher Leverage

- Firms can borrow subject to their default probability not exceeding θ
- Business owners are impatient and are at their borrowing constraint
- Since bigger firms have less uncertainty in over all sales growth, they borrow more per variety

Literature on Leverage

The positive relationship b/w firm size and leverage (contra Cooley and Quadrini (2001))

- Rajan and Zingales (1995), Dinlersoz, Kalemi-Ozcan, Hyatt, and Penciakova (2018) (contra Cooley and Quadrini (2001))

The negative relationship b/w firm size and sales-growth volatility

- Stanley et. al. (1996)

Negative relationship between volatility and leverage

- Leland (1994)

Larger firms generate fewer startups

- Elfenbein, Hamilton, and Zenger (2010), Gompers, Lerner, and Scharfstein (2005)

Low interest rates and misallocation

- Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017)

Some Background Literature

Secular trends

- ↑ business concentration: Autor, Dorn, Katz, Patterson, and van Reenen (2017)
- ↓ startup rate: Decker, Haltiwanger, Jarmin, and Miranda (2014), Hathaway and Litan (2014)
- ↓ in the return on safe assets: Del Negro, Giannone, Giannoni, and Tambalotti (2017), Eichengreen (2015)

Existing explanations of rising concentration ...

- Gutierrez and Philippon (2017), De Loecker and Eeckhout (2017)

... and of falling startup rates

- Karahan, Pugsley, and Sahin (2016), Neira and Singhania (2017), Kaymak and Schott (2018)

DATA

Data

COMPUSTAT nonfinancial and nonutility firms reporting in USD and with sales and market value > 1 M $ (2015 $), 1978-2015

Variable	Description
SALES/TRNVR(net)	Sales
LT	Total Liabilities
DLC	Debt in Current Liabilities - Total
DLTT	Long-Term Debt - Total
CSHO	Common Shares Outstanding
PRCC_F	Price Close - Annual Fiscal
CHE	Cash and Short-Term Investments
PPEGT	Plant, Property and Equipment - Total (Gross)
lnSale	ln(SALES (Net))
Mkt_Val	CHSO*PRCC_F + LT
Leverage Ratio I	(LT - CHE)/Mkt_Val
Leverage Ratio II	(DLC + DLTT - CHE)/Mkt_Val
Cap_Ratio	PPEGT/Mkt_Val
VolSalesGrowth in t	|(SALES(t)-SALES(t-1)|/[SALES(t)+SALES(t-1)]

Relationship Between Size and Leverage

Dep Var	Lev I	Lev II	Lev I	Lev II
	Cross-Section		Panel	
lnSale	0.025	0.017	0.042	0.042
	(75.28)	(59.05)	(21.37)	(24.16)
Cap_Ratio	0.088	0.040	0.091	0.033
	(70.09)	(35.41)	(3.42)	(2.48)
Subindustry FE	Yes	Yes	No	No
Firm FE	No	No	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Num of Obs	173,419	173,168	178,608	178,349
Num of Groups	-	-	18,291	18,277
R^2	0.25	0.20	0.11	.07

Relationship Between Size and Volatility

Dep Vars	VolSaleGrowth	
	Cross-section	Panel
lnSale	−0.022	−0.048
	(-126.45)	(-46.04)
Cap_Ratio	-0.023	-0.015
	(-35.77)	(-3.35)
Subindustry FE	Yes	No
Firm FE	No	Yes
Year FE	Yes	Yes
Num of Obs	158, 344	162,044
Num of Groups	-	16,896
R^2	0.16	0.12

MODEL

Model Elements

Sub-period 1

- (K, B): Number of varieties owned and net assets
- With prob $p(K)$ an idea is generated in the firm
  - $p(0) = 0$ and $p(K)$ is increasing in K
- If the idea is implemented in the firm, it succeeds with prob $s \sim U[s_{\min}, 1]$
- If the idea is implemented in a startup it succeeds with prob σ

Model Elements

Sub-Period 1: Sale vs Startup (Chatterjee and Rossi-Hansberg (2012))

- Let $W(K, B)$ be the value of the firm with K varieties at the beginning of the second subperiod
- Let s^* solve:

$$s^*[W(K+1, B) - W(K, B)] = \sigma W(1, 0)$$

- If $s > s^*(K, B)$, the idea is purchased for $\sigma W(1, 0)$ and implemented in the firm
- Else, the idea is implemented in a startup

Model Elements

Sub-Period 2: Product extinction shock

- The firm arrives with (K, B) or $(K+1, B)$
- Any variety can go extinct with prob ϕ
- Varieties remaining after extinction shocks is K'

Model Elements

Sub-Period 2: Choice of B'

$$V(K', B) = \max_{B'} \pi K' + \max B - q(K', B')B' + \beta\Omega(K', B')$$

s.t.

$$\pi K' + B - q(K', B')B' \geq 0$$

$$d(K', B') \leq \theta.$$

First constraint: No access to outside equity

Second constraint: Probability of default on debt cannot exceed θ

If the choice set is empty, the firm is in default

Model Elements

Sub-Period 2: Default Decision

$G(K')$ is the max revenue from bond issuances s.t. risk of default not exceeding θ

$$G(K') = \max_{B'} q(K', B')(-B')$$
$$\text{s.t.}$$
$$d(K', B') \leq \theta.$$

Then $\pi K' + G(K')$ is the maximum cash the firm can raise this period.

Default is triggered if $(-B) > [\pi K' + G(K')]$

Lenders get $(\pi K' + G(K'))/(-B)$ per unit of debt

Model Elements

Sub-period 2: Determination of $q(K', B')$

Let Q be the recovery rate on a unit bond

$$Q(K'', B') = \begin{cases} 1 & \text{if } B' \geq \bar{B}(K'') = 0 \\ \frac{\overline{B}(K'')}{B'} & \text{otherwise} \end{cases}$$

Then,

$$q(K', B') = (1+r)^{-1} \sum_{K''=0}^{K'+1} Q(K'', B') \Pr(K''|K', B').$$

Model Elements

Closing the Model

- $$p(K) = \begin{cases} \rho K & \text{if } \rho K < 1 \\ 1 & \text{o/w} \end{cases}$$

- ρ solves:

  $$M = \sum_K [\rho K] \times H_\rho(K)$$

  where $H_\rho(\cdot)$ is the steady state firm-size distribution

- We keep M constant across experiments

CALIBRATION

Calibration

Calibrate to 1997

Independently set parameters:

$$r = 0.0216,\ \beta = 0.95,\ M = 120,\quad s_{\min} = 0.89$$

Jointly set parameters:

Description of Target	Data/Model	Parameter	Value
Survival rate of 1-yr old firms in '97	0.843*	ϕ	0.195
Response of leverage to size	0.025	θ	0.035
Annual entry rate of new firms in '97	0.111*	σ	0.93

*: From BDS

Calibration

Non-Targeted Moments

Moments	Data	Model
Resp of sales volatility to size (x-section)	-0.022	$-0.028^{\dagger}$
Resp of sales volatility to size (panel)	-0.047	-
Average Leverage Ratio I	0.283	0.035
Average Leverage Ratio II	0.085	0.035

†: Excludes 1-variety firms

Calibration

Non-Targeted Moments

Moments	Data	Model
Survival rate of 0-yr old firms*	0.77	0.83
Survival rate of 2-yr old firms*	0.87	0.86
Survival rate of 3-yr old firms*	0.88	0.87
Survival rate of 4-yr old firms*	0.90	0.88

*: From BDS

Calibration

Non-Targeted Moments

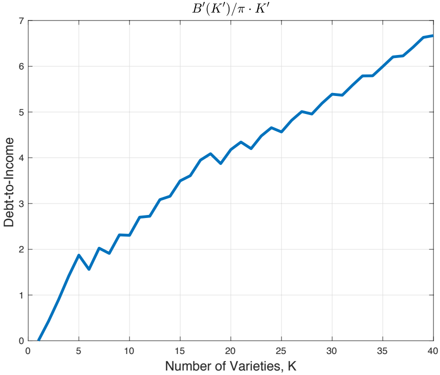
Moments	Data	Model
Empl growth of 0-yr old firms*	0.99	0.93
Empl growth of 1-yr old firms*	0.92	0.93
Empl growth of 2-yr old firms*	0.93	0.94
Empl growth of 3-yr old firms*	0.94	0.94
Empl growth of 4-yr old firms*	0.96	0.94

*: From BDS.

Empl growth in t-yr old firms: Total empl of $(t+1)$-yr old firms in 1997 $\div$ total empl in t-yr old firms in 1996

Model Properties

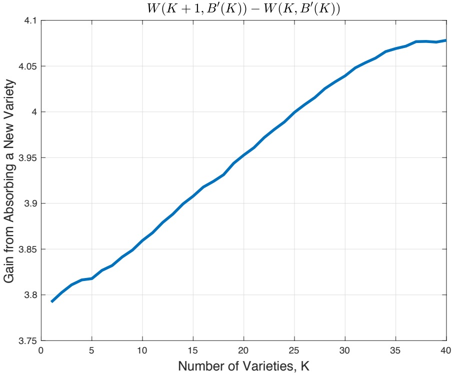
Debt-to-Income Ratio and Firm Size



- Surviving varieties next period as a prop of K' is roughly $(1-\phi)(1+\rho)$ on average and its variance is $[\phi(1-\phi)/(1+\rho)K']$
- Variance declines with K'

Model Properties

Positive Relationship between Size & Gain from Absorbing a New Variety



- The reason is that larger firms are able to borrow a greater fraction of the pdv of a variety's cash flow

APPLICATION

Application

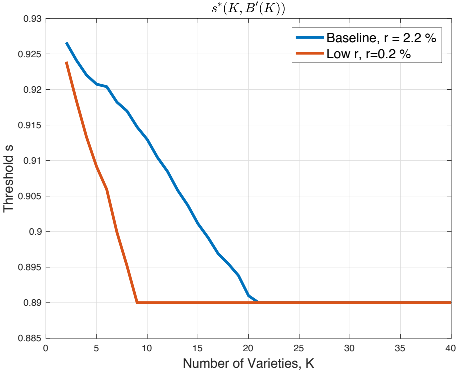
Implications of a Decline in r

- A drop in r means that firms sell debt for a higher price
- Since larger firms issue proportionately more debt, they purchase a larger fraction of new ideas
- Implies lower startups and higher concentration

Application

Implications of a Decline in r

Firm Size & Threshold s

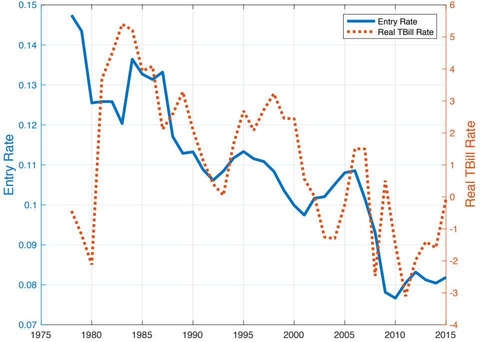


- Larger firms generate fewer startups (Elfenbein, Hamilton, and Zenger (2010), Gompers, Lerner, and Scharfstein (2005))

Application

Why Is This Relevant?

Risk-Free Rate & Entry

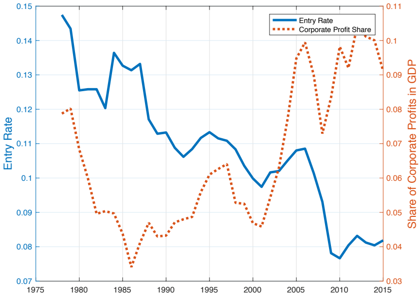


- Decline in both r and startup rates
- Decline in r accelerated in the late 1990s: Caballero, Farhi, and Gourinchas (2008), Mendoza, Quadrini, and Ríos-Rull (2009), Eichengreen

Application

Why Is This Relevant?

Share of Corporate Profits in GDP



- A puzzle for most theories of entry: high profits $\Rightarrow$ more entry
- In our model also, high profits could potentially increase M and, therefore, entry
- But our model also features another channel: where new varieties are implemented

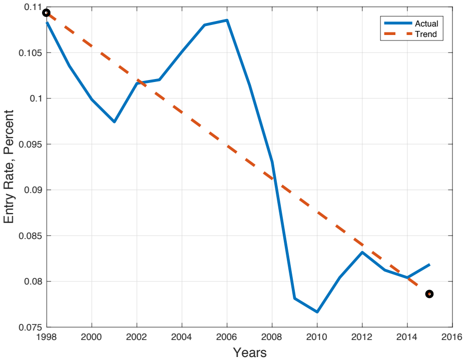
Application

Assessing the strength of the interest rate channel

- We take the drop in the risk-free rate to be about 2 percent since 1997
- We picked $s_{\min}$ so that this decline in r generates the drop in the trend entry rate from 1997 to 2015
- Why $s_{\min}$? Because the width of the support of s determines how much entry rate moves in response to a change in s^*
- We keep M – number of new ideas arriving per period – fixed

Application

Trend in Startup Rates: Data and Model

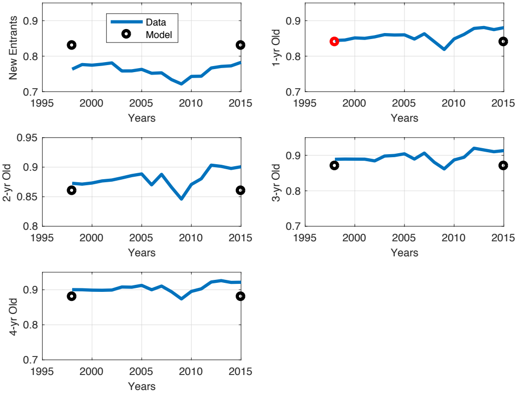


- First dot: Trend startup rate in 1997; model matches it by our calibration to 1997 data

- Second dot: Trend startup rate in 2015; model can match it by choice of $s_{\min}$ and the 2 percentage point decline in r

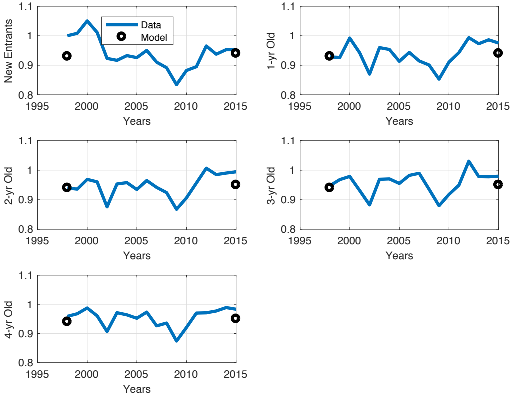
Application

Survival Rates: Model and Data



Application

Employment Growth: Model and Data



Application

Survival Rates: Model and Data

	Data 1997	Data 2015	Baseline	Low r
Survival rate of 0-yr old firms	0.77	0.76	0.83	0.83
Survival rate of 1-yr old firms	0.84*	0.87	0.84*	0.84
Survival rate of 2-yr old firms	0.87	0.89	0.86	0.86
Survival rate of 3-yr old firms	0.88	0.91	0.87	0.87
Survival rate of 4-yr old firms	0.90	0.91	0.88	0.88

*: Targetted

Application

Employment Growth: Model and Data

	Data 1997	Data 2015	Baseline	Low r
Empl growth of 0-yr old firms	0.99	0.90	0.93	0.94
Empl growth of 1-yr old firms	0.92	0.95	0.93	0.94
Empl growth of 2-yr old firms	0.93	0.97	0.94	0.95
Empl growth of 3-yr old firms	0.94	0.98	0.94	0.95
Empl growth of 4-yr old firms	0.96	0.96	0.94	0.95

Application

Implications for Business Concentration

	Measure of Firms	Share of Output Baseline	Share of Output Low r
Top 1% by Size in Baseline	2.05	0.16	0.21
Top 5% by Size in Baseline	10.23	0.34	0.70
Top 10% by Size in Baseline	20.46	0.45	0.88
Measure of Varieties		520.93	518.55

Conclusions

- The random arrival of new products and exit of old products generate entry, growth and exit of firms
- Larger firms are less risky and can (and do!) borrow more per variety, giving rise to the positive association between firm-size and leverage
- A decline in the risk-free rate makes purchasing a variety more attractive for firms, resulting in fewer startups and greater concentration of sales

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