Leverage and Productivity

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[1]These views are those of the author and do not necessarily reflect the views of the Federal Reserve System.

Questions

1. Can more productive firms borrow more?

2. What is the aggregate productivity loss due to financial frictions?

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Findings

1. For young and unlisted firms in Japan:
    - leverage rises almost one-for-one with productivity
    - output-to-capital ratio rises strongly with productivity
2. Implications within a standard macro framework:
    - more productive firms can borrow more
    - the constant leverage model overstates aggregate productivity loss from financial frictions by 30%

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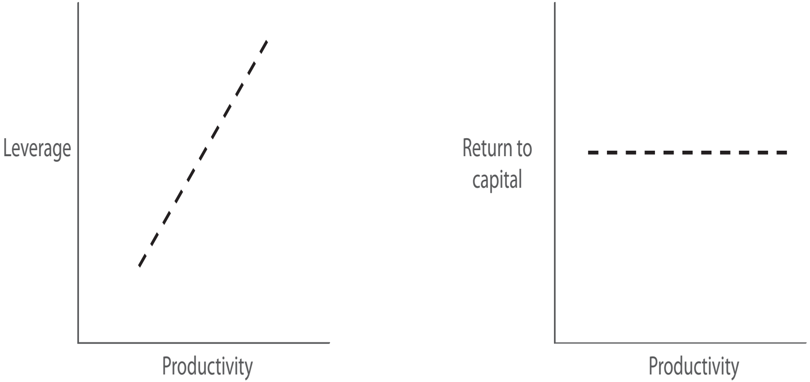
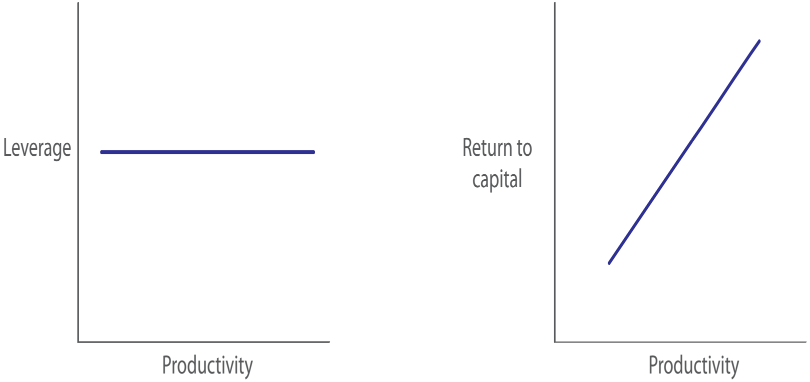
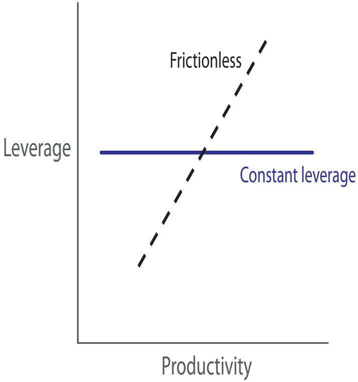
Frictionless

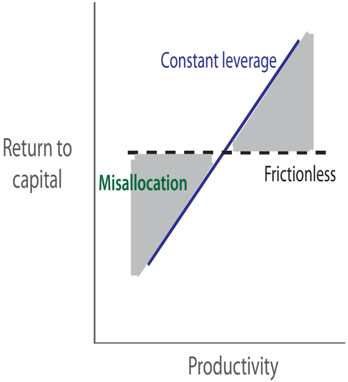


Constant leverage

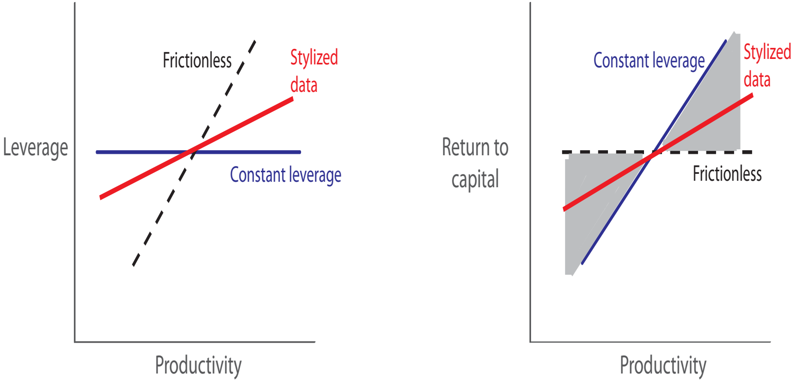


Frictionless vs Constant leverage





Polar Models versus Data



frictionless	my finding	constant leverage
0%	10.1%	13.7%

Table: aggregate productivity loss

Related Literature

Aggregate and firm dynamics implications of financial frictions: Buera et al (2011, 2014), Buera & Shin (2013), Midrigan & Xu (2014), Moll (2014), Gavazza & Violante (2014), Shourideh & Zetlin-Jones (2012), Arellano et al (2012), Bernanke & Gertler (1989), Holmstrom & Tirole (1997), Fang (2010), Herrera, Kolar and Minetti (2015), Greenwood et al (2013), Cooley & Quadrini (2001), Marimon et al (2004), Alburqurque & Hopenhayn (2004)

Empirical corporate finance and banking: Frank & Goyal (2008), Pushner (1995), Bates (1990), Astebro & Bernhardt (2003), Brav (2009), Ang et al (2010), Cassar (2004), Cole (2013), Berger et al (2011), Berger & Frame (2007), Fazzari et al (1988), Doblas-Madrid & Raoul Minetti (2013), Beck et al (2005, 2008), Herranz, Krasa & Villamil (2008, 2014), Hennessy & Whited (2007), Kaplan & Zingales (1997), Faulkender & Wang (2006), Gomes (2001), Petersen & Faulkender (2012)

Contribution

New facts: leverage and output-to-capital ratios rise with *productivity* for *young and unlisted firms* in *Japan*

Use the new facts to *discipline macro* models of financial frictions

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Roadmap

- Model
- Quantification
  - Empirical patterns
  - Indirect inference
- Aggregate implications

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Environment

A continuum of entrepreneurs

- infinitely-lived, CRRA utility
- can operate one business with Cobb-Douglas production technology
- idiosyncratic productivity
- can save and borrow

L workers, hand-to-mouth, each supply one-unit of labor

Aggregate output equals the sum of entrepreneur's output.
No aggregate shocks.

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Entrepreneur's problem

$$V(a,z) = \max_{a',c} u(c) + \beta \; \mathbb{E} \left[V(a',z') | z \right]$$

subject to

$$c + a' \leq a(1+r) + \pi(a,z)$$

$$\ln z' = \rho \ln z + \epsilon, \quad \epsilon \overset{iid}{\sim} N(\mu_e, \sigma_e^2)$$

where

$$\pi(a,z) := \max_{k,l} z(k^{\alpha} l^{1-\alpha})^{\eta} - Rk - wl, \quad R := r + \delta$$

$$k \leq \bar{k}(a,z)$$

.

Policy functions

Unconstrained firms:

$$k(a,z) \propto z^{\frac{1}{1-\eta}} \qquad \eta\alpha\frac{y(a,z)}{k(a,z)} = R$$

Constrained firms:

$$k(a,z) = \bar{k}(a,z) \qquad \eta\alpha\frac{y(a,z)}{k(a,z)} = R + \mu(a,z)$$

$$R + \mu(a,z) \propto \frac{z^{\frac{1}{1-(1-\alpha)\eta}}}{\bar{k}(a,z)^{\frac{1-\eta}{1-(1-\alpha)\eta}}} \text{ if constrained}$$

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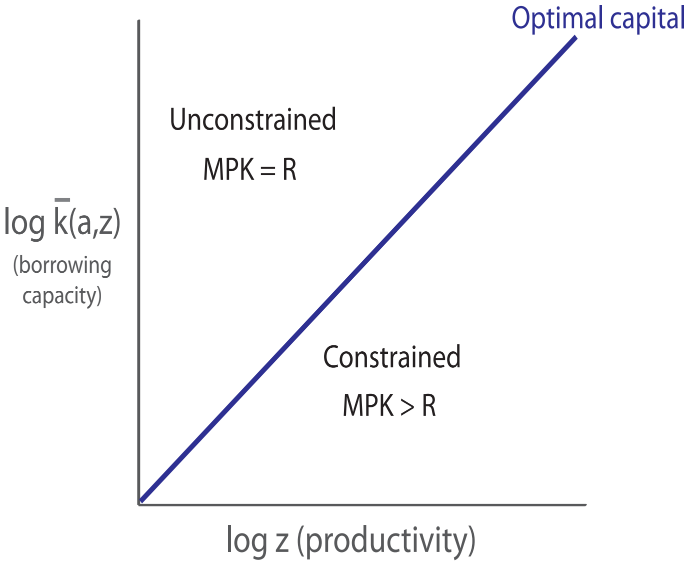
Financial constraint



Collateral constraint

If default, entrepreneurs keep $1 - \phi_y$ fraction of revenue, $1 - \phi_k$ fraction of depreciated capital, lose all inside equity

Can use financial market after one period without further penalties

$\bar{k}(a, z)$ is the maximum capital satisfying

$$\phi_y \max_l \{zf(k,l) - wl\} + \phi_k(1-\delta)k + (1+r)a \geq (R+1-\delta)k$$

$\phi_y = 1$, $\phi_k = 1$: unconstrained
$\phi_y = 0$: constant leverage model $k \leq \lambda a$

.

Stationary Equilibrium

A stationary competitive equilibrium consists of labor demand $l(a, z)$, capital demand $k(a, z)$, savings policy, interest rate and wage, wealth and productivity distribution $G(a, z)$ such that

1. given prices, $l(a, z)$, $k(a, z)$ and savings policy solve the entrepreneur's problem
2. capital market and labor market clear
3. $G(a, z)$ is consistent with the savings policy and the law of motion of z

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Firm-level data

- TSR-Orbis firm level data from Japan, 2004-2013
- TSR: Japan's largest credit rating agency
- unlisted limited liability companies and corporations
- age = years since incorporation
- unbalanced panel ▸ panel

.

Coverage

incorp year	TSR-Orbis	Census[1]
2001	8,995	35,114
2006	9,826	28,946
2011,2012	9,405	21,312

[1] single unit or main companies establishments

Table: Company counts. TSR-Orbis, Census

▸ shihonkin ▸ employment

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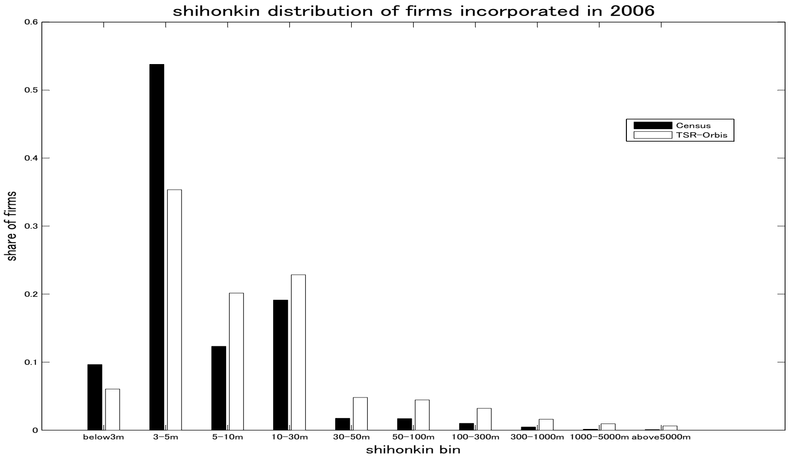
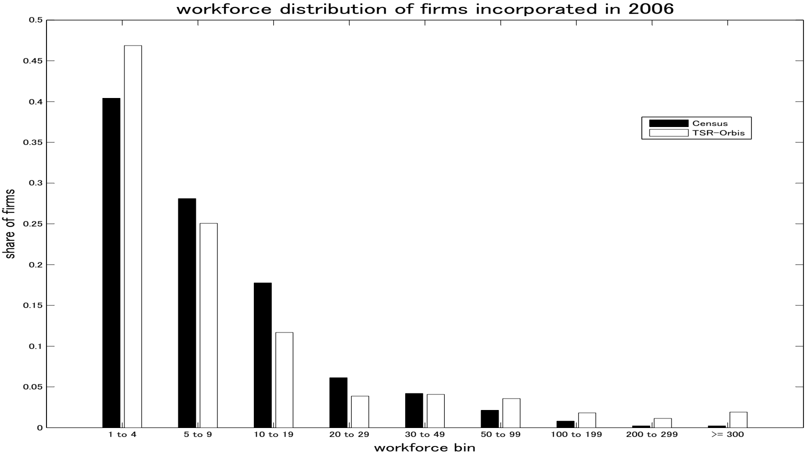
Entrant shihonkin distribution compared to the Census



return

Entrant workforce distribution compared to the Census



return

Definition of variables

- k = book value of capital stock (total asset)
- y = operating revenue × (1 - factor share of materials)
- l = number of employees
- $\ln z = \ln y - \eta\alpha \ln k - \eta(1-\alpha)\ln l$

  $\eta = 0.85$, α = factor share of capital in value added
- factor shares from JIP Database 2013, average over 2000-2010, 108 sectors
- a = *shihonkin* or shareholders fund ▸ shihonkin

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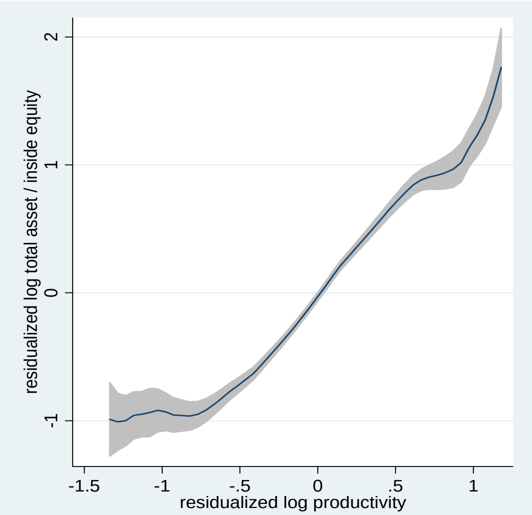
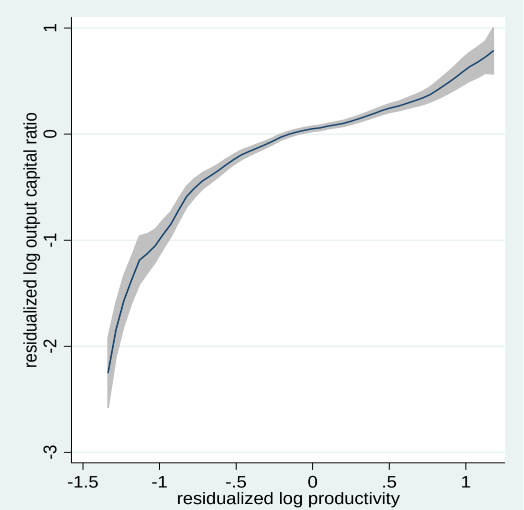
Firm leverage rises with firm productivity



Firm output-capital ratio rises with firm productivity



Regressions on log productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var	linear	quad.	diff a	diff k	firm FE	2SLS
leverage	1.125	1.120	0.973	0.346	0.489	0.207
	(0.039)	(0.050)	(0.040)	(0.051)	(0.034)	(0.048)
output-	0.690	0.598	0.751	1.316	1.126	3.205
capital	(0.028)	(0.035)	(0.032)	(0.039)	(0.034)	(0.684)
N	5872	5872	5872	5870	21962	5872

NAICS 6-digit industry FE. Control for log inside fund. 2SLS use employment to instrument for productivity. 2006 cohort. Age 5 except for (5). Similar results for other year-cohort.

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Indirect inference for ϕ_y and ϕ_k

Target: regression coefficients in the auxiliary model

$$\ln \frac{y}{k} = \beta_0 + \beta_1 \ln z + \beta_2 (\ln z)^2 + \beta_3 \ln a$$

$$\ln \frac{k}{a} = \theta_0 + \theta_1 \ln z + \theta_2 (\ln z)^2 + \theta_3 \ln a$$

$$[\hat{\phi}_y, \hat{\phi}_k] := \arg\min_{\phi_y, \phi_k} \quad ([\beta, \theta](\phi) - [\hat{\beta}, \hat{\theta}]) \Sigma ([\beta, \theta](\phi) - [\hat{\beta}, \hat{\theta}])^T$$

$\hat{\beta}$, $\hat{\theta}$: coefficients using empirical data

$\beta(\phi)$, $\theta(\phi)$: coefficients using data simulated from model with $(\phi_y, \phi_k) = \phi$

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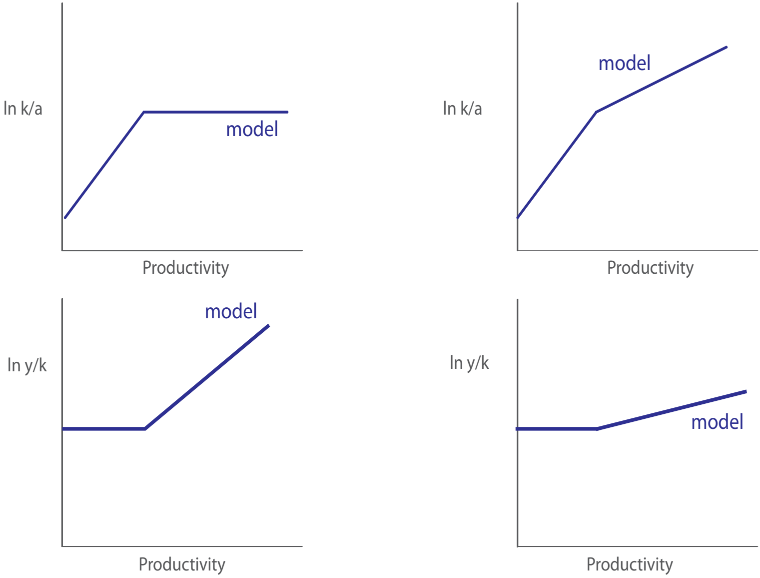
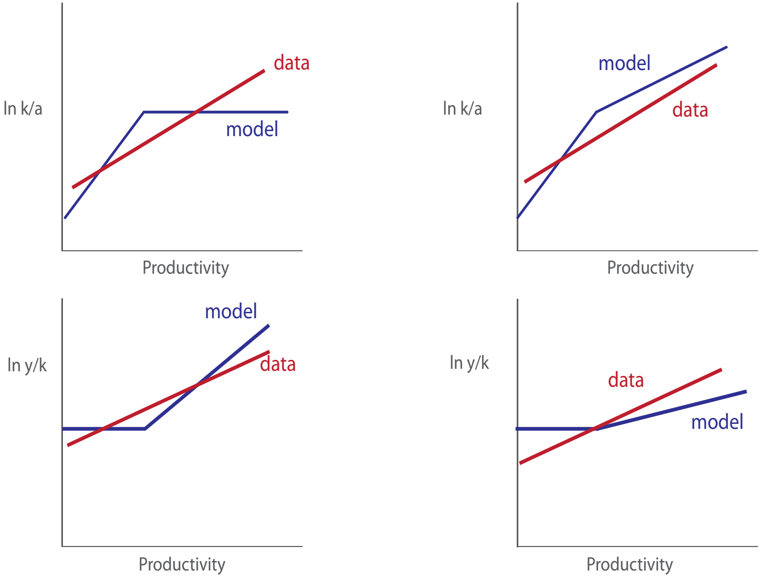
$\phi_y = 0$ $\qquad\qquad$ $\phi_y >> 0$



$\phi_y = 0$ $\qquad$ $\phi_y >> 0$



Fixed parameters

	Description	Value	Source
η	returns-to-scale	0.85	Midrigan & Xu (2014)
α	capital intensity	0.33	Midrigan & Xu (2014)
ρ	productivity persistence	0.95	Moll (2014)
σ	productivity dispersion	0.627	90/10 ratio of productivity

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Numerical routines

Solving the model:

- entrepreneur's problem: value function iteration with linear interpolation
- stationary distribution: Young (2013) non-stochastic forward iteration method
- eqm price: bisection on r and w

Finding the best parameters: brute force
for $(\phi_y, \phi_k) \in [0,1]^2$ with 0.1 increments

- solve model
- simulate data (using the same z history)
- run regressions

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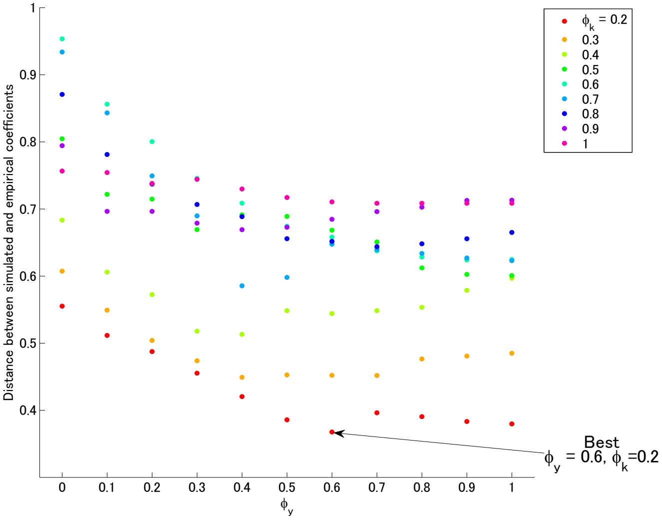
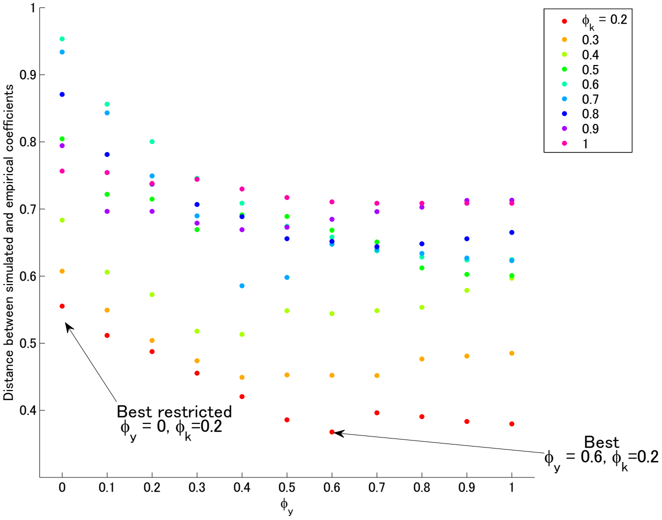
Distance on the (ϕ_y, ϕ_k) grid



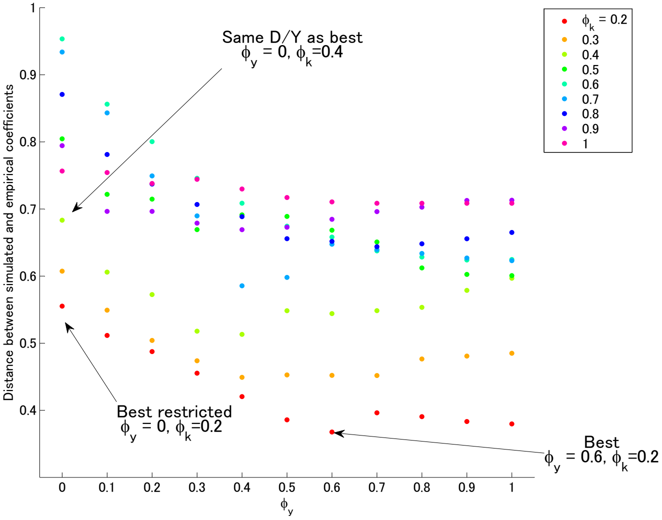
Distance on the (ϕ_y, ϕ_k) grid



Inference Results (OLS Weighting)

Regression	Coefficient value		
	best fit	$\phi_y = 0$	Data
	$\phi_y = 0.6,\ \phi_k = 0.2$	$\phi_y = 0,\ \phi_k = 0.2$	
Dep var $\ln \frac{k}{a}$			
$\ln z$	2.489	1.601	1.120 (0.050)
$\ln a$	-0.379	-0.303	-0.512 (0.018)
$(\ln z)^2$	-0.789	-1.206	-0.002 (0.013)
Dep var $\ln \frac{y}{k}$			
$\ln z$	1.456	1.765	0.598 (0.035)
$\ln a$	-0.275	-0.243	-0.206 (0.010)
$(\ln z)^2$	-0.216	0.420	-0.029 (0.008)
Distance	0.368	0.555	

Distance on the $(\phi_y,\ \phi_k)$ grid



Inference Results (OLS Weighting)

Regression	Coefficient value		
	best fit $\phi_y = 0.6,\ \phi_k = 0.2$	$\phi_y = 0$, same $\frac{D}{Y}$ $\phi_y = 0,\ \phi_k = 0.4$	Data
Dep var $\ln \frac{k}{a}$			
$\ln z$	2.489	1.823	1.120 (0.050)
$\ln a$	-0.379	-0.341	-0.512 (0.018)
$(\ln z)^2$	-0.789	-1.323	-0.002 (0.013)
Dep var $\ln \frac{y}{k}$			
$\ln z$	1.456	1.688	0.598 (0.035)
$\ln a$	-0.275	-0.230	-0.206 (0.010)
$(\ln z)^2$	-0.216	0.461	-0.029 (0.008)
Distance	0.368	0.683	

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TFP loss due to financial frictions

First best TFP

$$Z^{fb} := \left[\ \mathbb{E}_z\ z^{\frac{1}{1-\eta}}\right]^{1-\eta}$$

TFP loss from financial frictions

$$\text{loss} := \frac{Z^{fb} - Z}{Z}.$$

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TFP loss (OLS weighting)

TFP loss from financial frictions

$$\text{loss} := \frac{Z^{fb} - Z}{Z}.$$

Assuming $\phi_y = 0$ overstates loss due to financial frictions

Best fit	Restricted	Restricted, same $\frac{D}{Y}$
$\phi_y = 0.6,\ \phi_y = 0.2$	$\phi_y = 0,\ \phi_k = 0.2$	$\phi_y = 0,\ \phi_k = 0.4$
10.1%	15.3%	13.7 %

Table: TFP loss relative to the first best

Output loss (OLS weighting)

Output loss from financial frictions

$$\text{loss} := \frac{Y^{fb} - Y}{Y}.$$

Assuming $\phi_y = 0$ overstates loss due to financial frictions

Best fit	Restricted	Restricted, same $\frac{D}{Y}$
$\phi_y = 0.6,\ \phi_y = 0.2$	$\phi_y = 0,\ \phi_k = 0.2$	$\phi_y = 0,\ \phi_k = 0.4$
5.0%	42.7%	35.3 %

Table: TFP loss relative to the first best

Robustness check (equal weighting)

Regression	Coefficient value		
	best fit $\phi_y = 0.5,\ \phi_k = 0.2$	$\phi_y = 0$ $\phi_y = 0,\ \phi_k = 0.3$	Data
Dep var $\ln \frac{k}{a}$			
$\ln z$	2.297	1.710	1.120 (0.050)
$\ln a$	-0.351	-0.318	-0.512 (0.018)
$(\ln z)^2$	-0.852	-1.253	-0.002 (0.013)
Dep var $\ln \frac{y}{k}$			
$\ln z$	1.532	1.727	0.598 (0.035)
$\ln a$	-0.226	-0.238	-0.206 (0.010)
$(\ln z)^2$	0.297	0.437	-0.029 (0.008)
Distance	0.516	0.574	

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Robustness check (equal weighting)

Assuming $\phi_y = 0$ overstates loss due to financial frictions

$\phi_y = 0.5,\ \phi_k = 0.2$	$\phi_y = 0,\ \phi_k = 0.3$
10.7%	14.6 %

Table: TFP loss relative to the first best

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Conclusion

For young and unlisted Japanese firms

- leverage increases with productivity
- output-capital ratio increases with productivity

Pattern is consistent with a model of leverage capacity increasing with productivity

Accounting for this empirical pattern matters for understanding TFP loss due to financial frictions

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