Do Financial Frictions Explain Chinese Firm Saving and Misallocation?

Yan Bai
University of Rochester
NBER

Dan Lu
University of Rochester

Xu Tian
University of Toronto

Oct 2016

Motivation

- Literature emphasizes that financial frictions:
  - Generate high saving and outflow of capital
    - Song et al. (2011), Buera and Shin (2010), Mendoza et al.(2009)
  - Generate misallocation and low TFP
    - Hsieh and Klenow (2009), Midrigan and Xu (2014)
- We revisit the question: do financial frictions explain China's high saving and capital misallocation?
- Literature either uses aggregate data or ignores firms' financing patterns

This Paper

- Use micro-level Chinese data to quantify financial frictions
- Study its implications on firms saving and capital misallocation
  - Focus on firm: firms saving account for 50 percent of total saving in China ▸ Firm Saving
- In terms of misallocation and TFP
  - Examine model generated MPK
  - Dispersion of MPK is not enough to measure misallocation
  - We argue that covariance between marginal product capital (MPK) and firm size matters for misallocation
    - Restuccia and Rogerson (2008): large TFP losses must be associated with positively correlated taxes and firm productivity

Empirical Findings

- Compared to SOE, POE
  - Have lower leverage
  - Pay higher interest rate
  - Grow faster
  - Have higher MPK
- Among POEs, relative to large firms, small firms
  - Have lower leverage
  - Pay higher interest rate
  - Grow faster
  - Have higher MPK

Note that these patterns are not easily reconcile with exogenous borrowing constraints, for example collateral constraints

Model with Endogenous Borrowing Constraints

- We develop a model with heterogenous firms and financial frictions including
  - Endogenous default risk
  - Fixed credit cost of borrowing
- Default risk generates endogenous borrowing constraints and differential interest rates across firms
- Higher credit cost leads to more correlated leverage and size

Quantify Financial Frictions in China

- We estimate the model with observed firm financing patterns and firm distribution
- Financial frictions can explain aggregate firm saving and co-movement between saving and investment across firms
- Financial frictions generate 60% of observed MPK dispersion, but an opposite MPK-size relationship
  - TFP loss depends on both dispersion and covariance
  - Intuitively, given the same MPK dispersion, whether subsidize small and tax large firms, or subsidize large and tax small, have different implications on TFP loss

Literature

- Saving: Song et al. (2011), Buera and Shin (2010), Mendoza et al.(2009)
- Misallocation: Restuccia and Rogerson (2008), Restuccia and Rogerson (2013), Adamopoulos, Brandt, Leight, and Restuccia (2015), Hsieh and Klenow (2009), Midrigan and Xu (2014)
- Firm dynamics and financial frictions: Cooley and Quadrini (2001), Arellano, Bai, and Zhang (2010)

This paper: use micro level data and firm financing patterns to discipline financial frictions

Data

Chinese Manufacturing Firms

- Balance sheet data 1998-2006
  - SOE: State Owned enterprises, including sole state funded, state joint ownership and state and collective joint ownership
  - POE: private enterprises, including sole private, private partnership, private limited liability and private shareholding corporations

Chinese Manufacturing Firms

- Key variables:
  - Leverage $= \frac{\text{liability}}{\text{asset}}$ Interest rate $= \frac{\text{interest payment}}{\text{liability}}$
  - Marginal product of capital

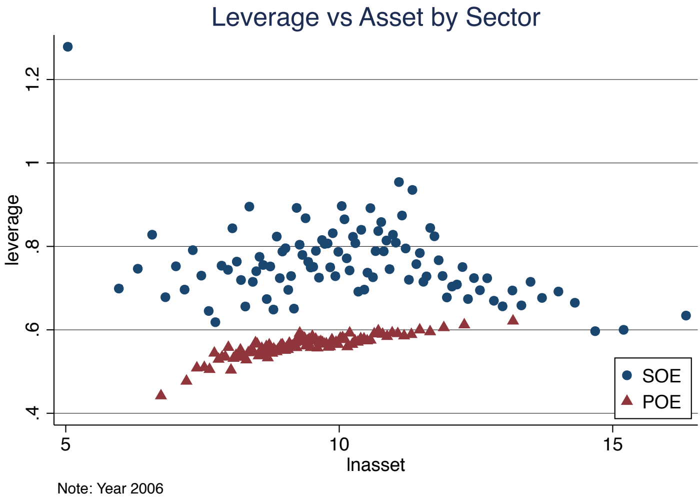
$$\log[MPK_{ij}] = \log(\alpha_j) + \log\left(\frac{Y_{ij}}{K_{ij}}\right)$$

α_j: sector j average capital share or industry fixed effect

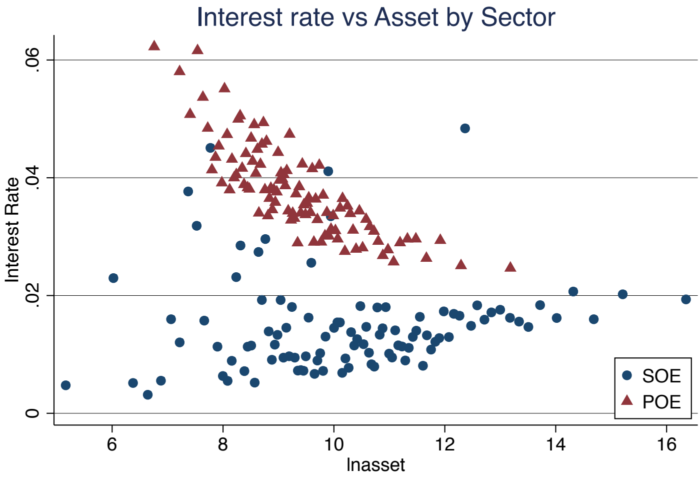
$$\log[MPK_{ij}] - \log[\overline{MPK}_j] = \log\left(\frac{Y_{ij}}{K_{ij}}\right) - \log\left(\overline{\frac{Y_j}{K_j}}\right)$$

Y_{ij}: value added of firm i at sector j
K_{ij}: fixed asset of firm i at sector j
$\overline{\frac{Y_j}{K_j}}$: sector j's average value added-capital ratio

Leverage and Size

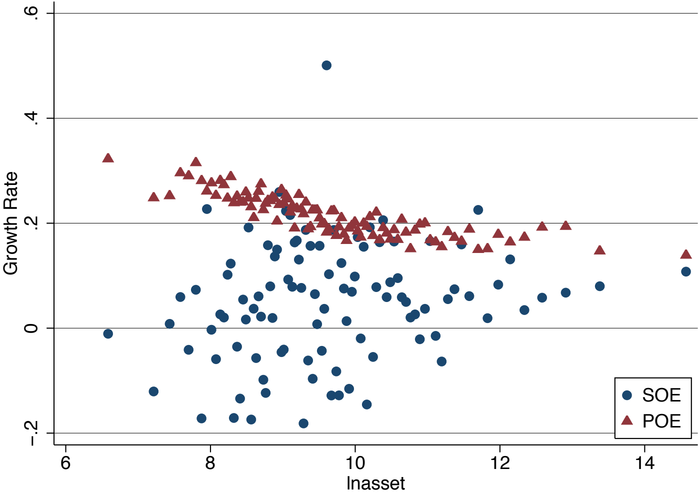


Interest Rate and Size

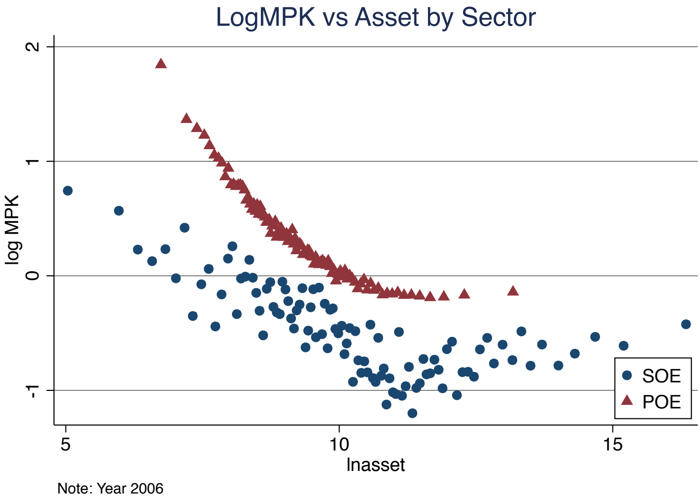


Note: Year 2006

Growth Rate and Size



MPK and Size


LogMPK vs Asset by Sector
log MPK
2
1
0
-1
5
10
15
lnasset
SOE
POE
Note: Year 2006

Regression, Year 1999

	Leverage	Interest Rate	Growth Rate	log MPK
lnasset	.036***	-.019***	-.029***	-.446***
	(6.65)	(-6.99)	(-3.87)	(-17.63)
SOE	.57***	-.215***	-.595***	-3.52***
	(9.38)	(-8.23)	(-7.63)	(-14.77)
SOE*lnasset	-.039***	.020***	.045***	0.261***
	(-7.35)	(7.36)	(5.4)	(9.94)
Observations	47,542	47,542	38,572	47,542
Industry FE	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Regression, Year 2006

	Leverage	Interest Rate	Growth Rate	log MPK
lnasset	.018***	-.006***	-.021***	-.341***
	(8.17)	(-3.68)	(-6.92)	(-26.59)
SOE	.566***	-.089***	-.475***	-2.37***
	(11.58)	(-5.07)	(-7.13)	(-10.63)
SOE*lnasset	-.036***	.006***	.033***	0.181***
	(-7.92)	(4.20)	(5.02)	(8.49)
Observations	142,009	142,009	112,368	142,009
Industry FE	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Summary of Firm Level Data

- Compared to SOE, POE
  - Have lower leverage
  - Pay higher interest rate
  - Grow faster
  - Have higher MPK
- Among POEs, relative to large firms, small firms
  - Have lower leverage
  - Pay higher interest rate
  - Grow faster
  - Have higher MPK
- These patterns also hold for other years

Model

- Note that these patterns are not easily reconcile with exogenous borrowing constraints
- Build a model with endogenous borrowing constraints
  - Discipline the model with firms financing patterns
- Examine firms saving, the MPK and misallocations under the model
  - The observed MPK could be affected by many other distortions

A Simple Theory on Misallocation

- Heterogenous firms with $y_i = z_i^{1-\alpha} k_i^{\alpha}$
- From definition of MPK, $\quad k_i = (\alpha)^{\frac{1}{1-\alpha}} z_i \; MPK_i^{\frac{1}{\alpha-1}}$
- TFP

$$TFP = \frac{Y}{K^{\alpha}} = \frac{\int_i z_i \; MPK_i^{\frac{\alpha}{\alpha-1}} d_i}{\left(\int_i z_i \; MPK_i^{\frac{1}{\alpha-1}} d_i\right)^{\alpha}}$$

- Efficient TFP: $MPK_i = MPK_j$

$$TFP^e = \left(\int_i z_i d_i\right)^{1-\alpha}$$

- TFP loss

$$\text{TFP loss} = \log(TFP^e) - \log(TFP)$$

Model

Model

- Heterogenous firms in two sectors: SOE and POE
- Firms produce with DRS technology and finance investment and dividend payouts with internal funds and loans from banks
- Financial market is imperfect
    - Firms can only borrow state-uncontingent bond
    - SOEs are not allowed to default as long as they are able to repay their debts
    - POEs can default on their loans
    - Banks provide debt schedules taking into account default risks of firms and fixed cost of issuing loans

Production

- Firms produce output using capital as input,

$$y = zk^{\alpha}$$

- z have a constant growth rate, a permanent component A_i, and an idiosyncratic component

$$z_{it} = (1+g)^t A_i \nu_{it}$$

  - ν : following a Markov process given by $f(\nu'; \nu)$

POE Firms' Problem

- POEs can default over their loans b; after default
  - Still operate, but productivity reduced by γ fraction
  - Lose access to financial markets, λ prob. regain access
- Default decision

$$V(z,k,b) = \max_{d\in\{0,1\}} (1-d)\,V^c(z,k,b) + dV^d\,(z,k)$$

  - $d = 0$ not default
- Defaulting value

$$\begin{aligned} V^d\,(z,k) &= \max_{x,k'} \quad x + \beta E\left[(1-\lambda)\,V^d(z',k') + \lambda V^c(z',k',0)\right] \\ st \quad x &= (1-\gamma)zk^\alpha + (1-\delta)k - k' - \phi(k,k') \geq 0 \end{aligned}$$

POE Firms' Problem

- Repaying value

$$V^c(z,k,b) = \max_{x,k',b'} \quad x + \beta EV(z',k',b')$$
$$st \quad x = zk^\alpha + (1-\delta)k - b + q(z,k',b')b' - k' - \phi(k,k') \geq 0$$

- Debt price schedule $q(z,k',b')$ reflects default risk

SOE Firms

- SOE firms never default

$$
\begin{aligned}
W(z,k,b) &= \max_{x,k',b'} \quad x + \beta E W(z',k',b') \\
st \quad x &= zk^{\alpha} + (1-\delta)k - b + q(z,k',b')b' - k' - \phi(k,k') \geq \\
b' &\leq \bar{B}(z,k')
\end{aligned}
$$

- Nature borrow constraint guarantees the firms with the maximum borrowing limits are able to repay their debt

Banks

- Banks are competitive and risk neutral. Banks need to pay a fixed cost ξ for every loan they offer, which captures banks' overhead cost and the cost for obtaining information for each loan.
- For SOEs:
$$q(z, k', b') + \xi = \frac{1}{1+r}.$$

Banks

- For POEs,

- When saving $b' \leq 0$

$$q = \frac{1}{1+r}$$

- When lending, have to pay a fixed cost ξ
- Prices reflect both default risk and fixed cost

$$q(z, k', b')b' + \xi = \frac{b'}{1+r}\left[1 - \int d\left(z', k', b'\right) f\left(z'; z\right) dz'\right].$$

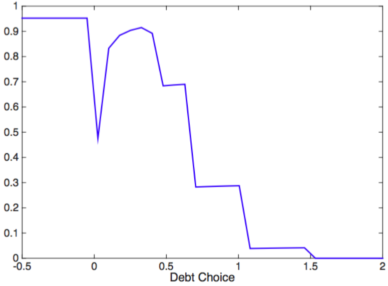
Equilibrium

Definition: A recursive equilibrium consists of decision rules and value functions of firms, and bond price schedule $q(z, k', b')$ such that

1. Given the bond price schedule, the decision rules and the value functions solve each firm's problem.

2. Given interest rate and the decision rules, the bond price schedule makes banks break even in expected value.

Debt Price Schedule



- Small loans have high interest rate due to fixed cost
- Very large loans also have high interest rate due to default

Quantification

Shock structure

A firm's productivity

$$z_{it} = (1+g)^t A_i \nu_{it}$$

- Permanent A_i follows Pareto distribution

$$Pr(A_i \leq x) = 1 - x^{-\mu}$$

- Idiosyncratic component ν_{it}

$$log(\nu_{it}) = \rho \log(\nu_{it-1}) + \sigma \varepsilon_{it}, \qquad \varepsilon_{it} \sim N(0,1)$$

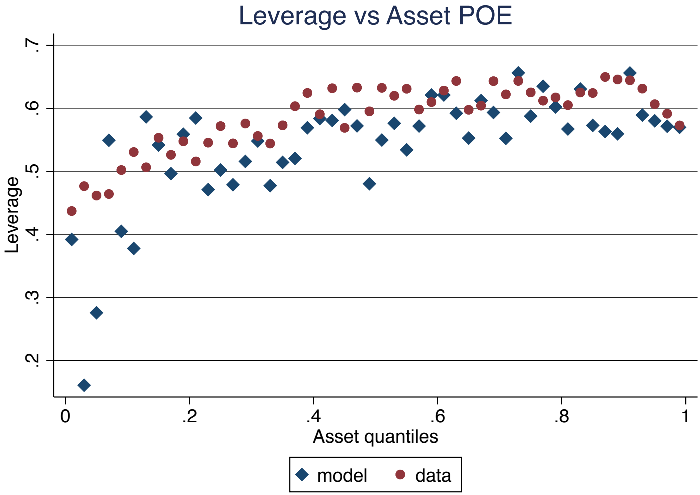
Calibration

Calibrated Parameters	Value	Description
α	0.33	production function curvature
λ	0.1	reentry probability
δ	0.1	depreciation rate
r	0.05	riskfree rate
ρ	0.85	persistence of productivity shock
		Gopinath et al (2015)
g	0.07	growth rate
Estimated Parameters		
β	0.94	discount factor
γ	0.3	output loss
ξ	0.012	fixed credit cost
ϕ	1.3	capital adjustment cost
σ	0.76	shock standard deviation
μ	1.30	shape parameter for permanent A
A_6	0.8	the second largest value of A
A_7	0.92	the largest value of A

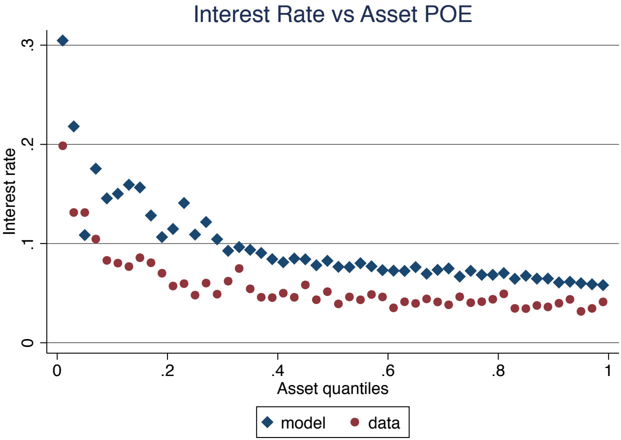
Model vs Data

Target Moments	Model	POE 1999 Data
Leverage	0.56	0.58
Leverage-Asset pct Slope	0.17	0.17
Interest-Asset pct Slope	-0.12	-0.08
Growth of value added		
Mean	0.14	0.13
Var	0.40	0.40
Distribution of value added		
TOP Percentiles	Fraction of value added	
5	0.34	0.34
10	0.48	0.46
20	0.66	0.62

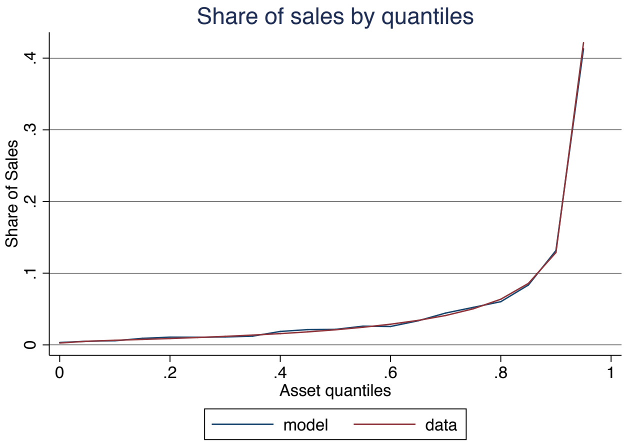
Leverage and Size



Interest Rate and Size



Sales Distribution

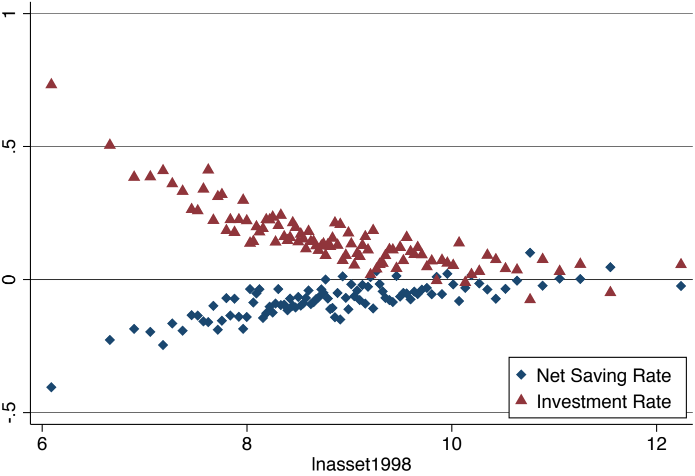


Model Implications on Saving

Non-Targeted Moments	Model	Data
Aggregate Statistics:		
Gross investment rate	0.15	0.18
Correlations		
Saving rate, Investment rate	0.28	0.58
Net saving rate, ln(asset)	0.16	0.15

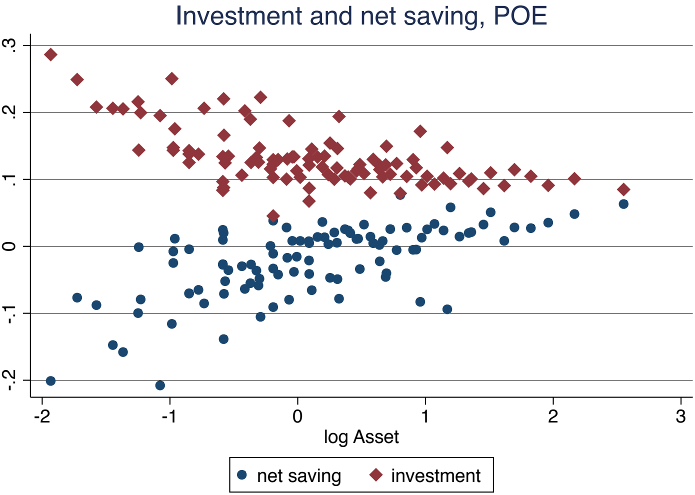
- Model generates co-movement of saving and investment
- Model matches well the co-movement of net saving and firms size

Investment, Saving and Size(Data)



Note: Year 1998-1999

Investment, Saving and Size(model)



Model Implications on MPK and Misallocation

Non-Targeted Moments	Model	Data
Aggregate Statistics:		
Dispersion of MPK	0.67	1.12
Correlations		
MPK, asset	0.20	-0.36
MPK, leverage	0.36	0.01

- Model generates 60% of the observed MPK dispersion
- In the model, large firms have higher MPK. In the data, small firms have higher MPK due to other reasons

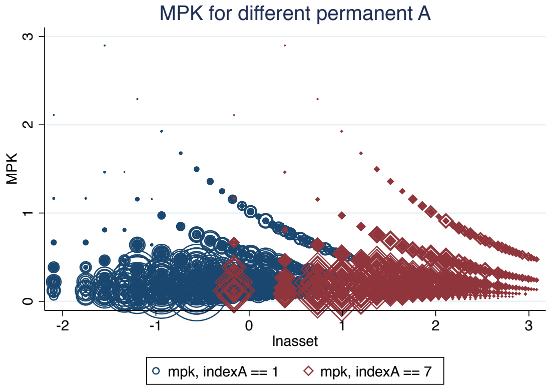
How MPK varies with size: rough intuition

$$E[MPK] = r + \delta + \underbrace{\phi f(K_{-1}, K)}_{\text{adjustment cost}} + \underbrace{\mu(A, K)}_{\text{financial frictions}}$$

- Marginal adjustment cost $\phi f(K_{-1}, K)$ increases with K
- Financial friction $\mu(A, K)$ could
  - Increase with K: higher default incentive
  - Decrease with K: relax limited liability condition

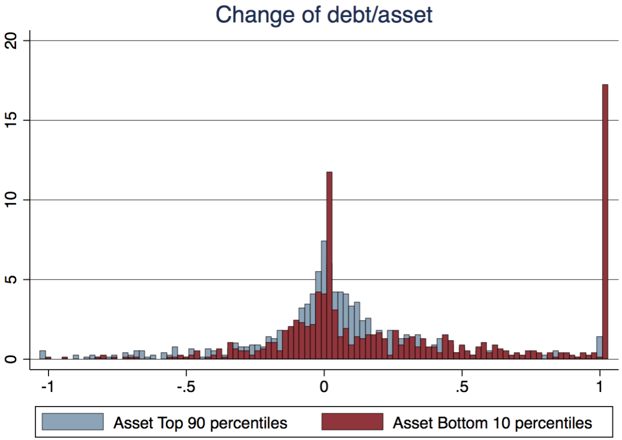
MPK across ν and A

- For each ν and A, MPK is downward sloping
- Within A, for different ν, MPK is upward sloping

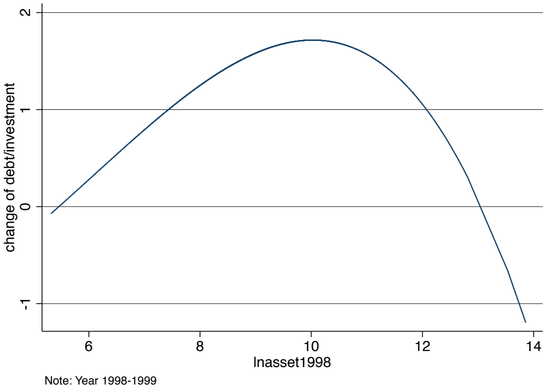


Fixed Issuing Cost

In the data, small firms' change of debt are more lumpy



Large Firms are also Distorted



Sensitivity Analysis

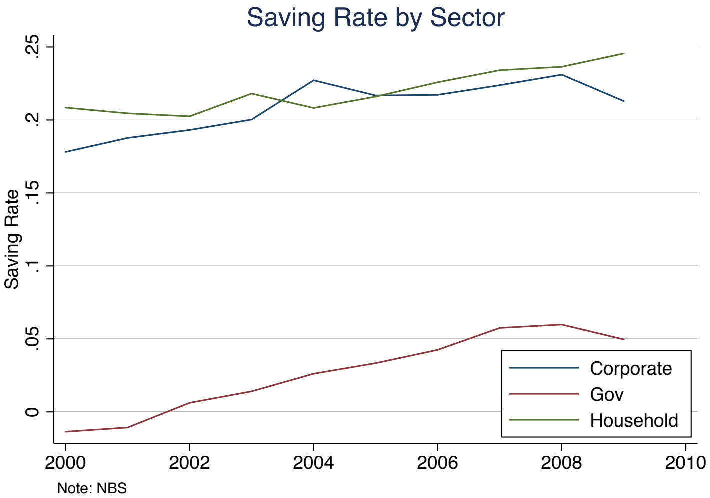
In our model, financial friction generate 4.14% of TFP loss due to misallocation.

- Span of Control and Labor Market
  - In our benchmark $\alpha = 0.33$, freely adjusted labor
  - $\alpha = 0.85$ (larger loss)
- Capital adjustment cost
  - In our benchmark, convex adjustment cost (we leave firms investment rates for out of sample test) could generate too small variance of investment rate and too small TFP loss.
  - In the data, lumpy investment
- Misallocation between SOE and POE
- Large amount of entrants

Conclusion

- We document debt financing, interest spread, and growth of Chinese firms relate to firms size
- We use firm level data to quantify the effects of financial frictions on firm saving and misallocation
- We find that financial frictions
  - play important role in firms saving and investment decisions
  - generate capital misallocation (although not all the dispersion in the data)

Saving Rates by Sectors



A Simple Theory on Misallocation

- Literature: z_i and MPK_i jointly log-normally distributed

$$\text{TFP loss} = \frac{1}{2}\frac{\alpha}{1-\alpha}var(logMPK_i)$$

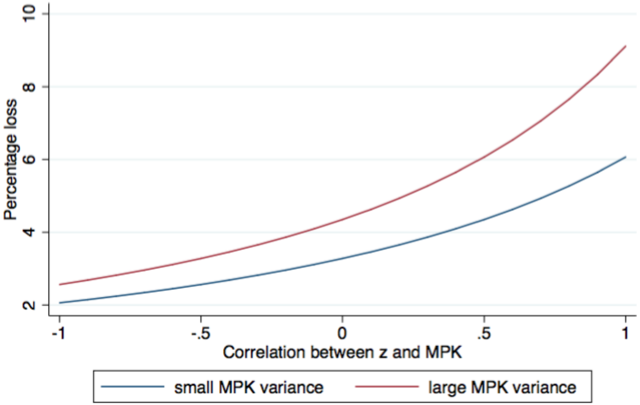
  - TFP loss only depends on dispersion of MPK

- Generally covariance of z and MPK also matters

  Eg: Assume MPK is Pareto distributed with parameter γ, and $z = MPK^{\rho}$

$$\text{TFP loss} = \frac{\gamma - \rho - \frac{\alpha}{\alpha-1}}{(\gamma-\rho)^{1-\alpha}\left(\gamma-\rho-\frac{1}{\alpha-1}\right)^{\alpha}}$$

Example: TFP Loss Under Pareto Distribution



- Same dispersion of MPK, but TFP loss varies with size-MPK correlation
- High ρ leads to large TFP loss since high z accounts more for output