Collateral Constraints and Asset Composition

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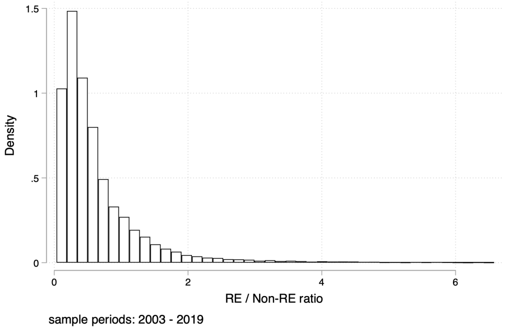
Capital Asset Composition of Chinese Listed Manufacturing Firms

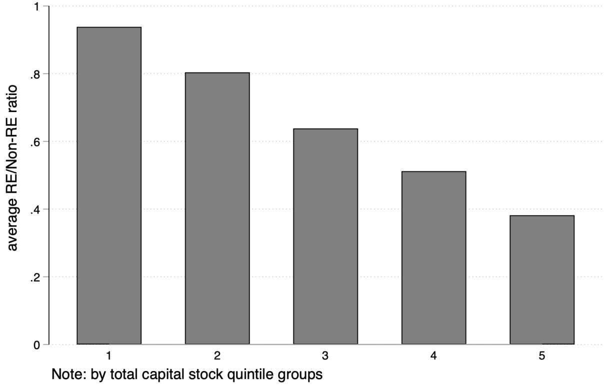


Source: Financial Reports of Listed Companies in China. Based on asset types classified by the author.

by industry

- Real Estate Capital (RE): Buildings, houses, and land
- Non-real Estate Capital (Non-RE): Equipment, machinery, and other facilities

Capital Composition and Capital Size



Source: Financial Reports of Listed Companies in China. Based on asset types classified by the author.

Introduction

Asset composition between real estate capital (RE) and non-real estate capital (Non-RE) for Chinese firms

- Distinct capital inputs for production.
- Distinct adjustment costs.
- Differences in pledgeability.
  - Credit constraints $\rightarrow$ firms' precautionary investment (Perez-Orive, 2016; Aghion et al., 2010)
  - Binding collateral constraints $\rightarrow$ capital investment (Gan, 2007; Chaney et al., 2012)

Research Questions

How do collateral constraints shape firms' investment allocation between RE and Non-RE?

- Effect of collateral constraints on aggregate outcomes.

How do variations in real estate pledgeability influence firms' overall capital investment decisions?

- Effect of change in RE pledgeability in China.

This Paper

- A capital adjustment model with two capital inputs.
  - CES aggregator in production
  - Convex and non-convex adjustment costs
  - Collateral constraints
- Estimates the revenue function and idiosyncratic shock process using GMM.
- Estimates adjustment costs and pledgeability parameters using SMM:
  $\Longrightarrow$ Compares the "Goodness of fit" across models with different frictions.
- Decomposes the effects of production technology, adjustment costs, and collateral constraints on asset composition.
- Performs a counterfactual exercise under a real estate crisis scenario.

Takeaways

- **RE and Non-RE are perfect complement in production.**
  - $\Rightarrow$ Optimal asset composition in a frictionless economy.
- **Higher fixed cost of adjusting real estate capital.**
  - equivalent to 24% of the period's cash flow if + investment.
  - $\Rightarrow$ Non-degenerate distribution of asset composition.
- **Higher pledgeability of real estate capital.**
  - RE secures external financing equivalent to 2.55 units of RE.
    Non-RE secures external financing equivalent to 2.33 units of Non-RE.
  - $\Rightarrow$ Smaller firms allocate a larger share of capital to real estate.

Takeaways

- **Effect of collateral constraints: By relaxing collateral constraints,**
  - Average RE/Non-RE ratio $\downarrow$ by 16%.
  - Aggregate productivity(TFPR) [1] $\uparrow$ by 5%.
    Aggregate capital $\downarrow$ by 4%.
    Aggregate revenue $\downarrow$ by 0.8%.

- **Effect of Δ in RE pledgeability: If RE is not pledgeable,**
  - Average RE/Non-RE ratio $\downarrow$ by 9%.
  - Aggregate productivity(TFPR) $\downarrow$ by 3.6%.
    Aggregate capital $\uparrow$ by 3%.
    Aggregate revenue $\downarrow$ by 0.3%.

[1] aggregation weighted by capital size.

Literature

- **Real Estate and Collateral Constraints:** Gan (2007), Chaney et al. (2012), Catherine et al. (2022), Wu et al. (2015), Chen et al. (2015)
  $\Rightarrow$ Endogenous decisions on real estate assets. Evidence for Chinese Economy.

- **Financial Frictions and Investment Composition:** Matsuyama (2007), Aghion et al. (2010), Perez-Orive (2016), Ottonello and Winberry (2023)
  $\Rightarrow$ Composition between RE and Non-RE.

- **Non-convex Adjustment Cost and Investment Lumpiness:** Abel and Eberly (1994), Doms and Dunne (1998), Cooper and Haltiwanger (2006), Yan (2012), Chiavari and Goraya (2021), Kermani and Ma (2023)
  $\Rightarrow$ Adjustment costs of RE and Non-RE.

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Revenue Function

- Idiosyncratic shock: z. $log(z_t) = \rho_z log(z_{t-1}) + \sigma_z \xi_t$,$\xi_t \sim N(0,1)$
- Non-real estate capital: k
- Real estate capital: h

Decreasing-return-to-scale Revenue Function

$$\pi(k,h,z) = z\{(a^{\frac{1}{\sigma}} k^{\frac{\sigma-1}{\sigma}} + (1-a)^{\frac{1}{\sigma}} h^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}\}^{\alpha},\ \alpha \leq 1.$$

- if $\sigma \to 0$, $min\{\frac{k}{a}, \frac{h}{1-a}\}$.
- if $\sigma \to +\infty$, $k + h$.
- if $\sigma \to 1$, $(\frac{k}{a})^a (\frac{h}{1-a})^{1-a}$.

Adjustment Costs

Cost of adjusting k

$$C(k,k') = \begin{cases} x_k + \frac{\gamma}{2}\frac{x_k^2}{k} + F_k k & \text{if } x_k \neq 0; \\ 0 & \text{if } x_k = 0; \end{cases}$$

Cost of adjusting h

$$\tilde{C}(h,h') = \begin{cases} p_h x_h + \frac{\omega}{2}\frac{x_h^2}{h} + F_h h & \text{if } x_h \neq 0; \\ 0 & \text{if } x_h = 0; \end{cases}$$

where $x_k = k' - (1-\delta_k)k$, and $x_h = h' - (1-\delta_h)h$.

- γ/ω: gradual building/installing process, capacity constraints of the seller, limitation of financial capacities...
- F_k/F_h: indivisibility, worker retraining, organizational restructuring...

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- F_k/F_h: indivisibility, worker retraining, organizational restructuring...

Firm's Problem

Extensive Margin

$$V(k,h,z) = max\{V^a(k,h,z), V^k(k,h,z), V^h(k,h,z), V^i(k,h,z)\}$$

- $V^a(k,h,z)$ is the value if adjusting k and h.
- $V^k(k,h,z)$ is the value if only adjusting k.
- $V^h(k,h,z)$ is the value if only adjusting h.
- $V^i(k,h,z)$ is the value of inaction.

Firm's Problem

Intensive Margin

$$V^a(k,h,z) = \max_{k',h'>0} \quad \pi(k,h,z) - C(k,k') - \tilde{C}(h,h') + \beta \mathbb{E} V(k',h',z')$$

$$s.t.\ C(k,k') + \tilde{C}(h,h') \leq \underbrace{\pi(k,h,z)}_{internal\ funding} + \underbrace{\phi_k k(1-\delta_k) + \phi_h p_h h(1-\delta_h)}_{external\ funding}$$

Firm's Problem

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$$V^k(k,h,z) = \max_{k'>0} \quad \pi(k,h,z) - C(k,k') + \beta \mathbb{E} V(k',h(1-\delta_h),z')$$
$$s.t.\ C(k,k') \leq \pi(k,h,z) + \phi_k k(1-\delta_k) + \phi_h p_h h(1-\delta_h)$$

$$\vdots$$

$$V^i(k,h,z) = \pi(k,h,z) + \beta \mathbb{E} V(k(1-\delta_k),h(1-\delta_h),z')$$

cash/debt dynamics in data

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Data

- Financial Reports of Chinese Listed Manufacturing Firms (CSMAR). Unbalanced panel with 2,137 firms and 21,783 firm-year observations from 2003 to 2019.
  - classification of Non-RE and RE from Financial Statement Appendix.
  - stock values of Non-RE (k) and RE(h) by perpetual inventory method:

$$k_{t+1} = k_t(1-\delta_k) + i_t^k; h_{t+1} = h_t(1-\delta_h) + i_t^h.$$

    where $\delta_k = 0.1275$ and $\delta_h = 0.0487$.
  - investment rate: $\frac{i_t^k}{k_t}; \frac{i_t^h}{h_t}$. Distribution Trend
  - variables adjusted for year-fixed effects.

Revenue Function Estimation

$$\pi(k,h,z) = z\{\underbrace{(a^{\frac{1}{\sigma}}k^{\frac{\sigma-1}{\sigma}} + (1-a)^{\frac{1}{\sigma}}h^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}}}_{\mathbf{K}}\}^{\alpha} = z\mathbf{K}^{\alpha},$$

$$log(z_t) = \rho_z log(z_{t-1}) + \sigma_z \xi_t$$

$$\Downarrow$$

$$log\pi_{it} = \rho_z log\pi_{it-1} + \alpha \cdot (log\mathbf{K}_{it} - \rho_z log\mathbf{K}_{it-1}) + \sigma_z \xi_t$$

Orthogonality conditions: ξ_t orthogonal to k_s, h_s, and π_{s-1}, $\forall s \leq t$.

Instruments: $log(k_s)$, $log(h_s), s \in \{t, t-1, t-2\}$; $log(\pi_s), s \in \{t-1, t-2\}$

Revenue Function Estimation

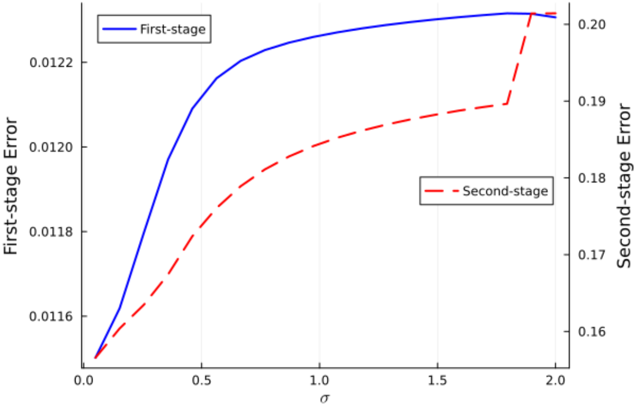
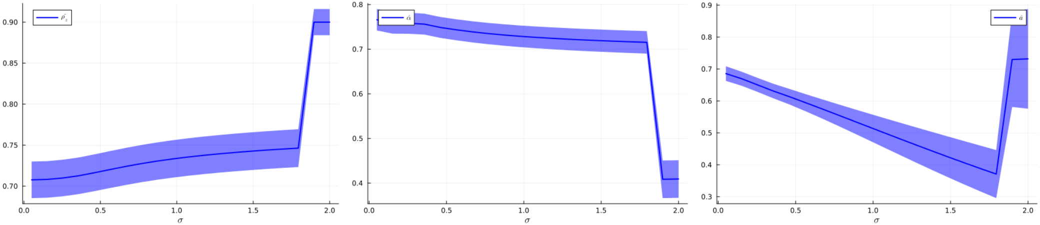


Figure: Objective Function

full table balanced panel

Revenue Function Estimation



(a) Estimate: ρ_z (b) Estimate: α (c) Estimate: a

Figure: Revenue Function Estimation

Note: The GMM is performed to estimate ρ_z, α, and a while fixing σ at different values. Panel (a), (b), (c) present the parameter estimates as functions of σ, with 95% confidence intervals included.

Pre-defined Parameters

	Value	Description	Source
β	0.9479	discount factor	$\frac{1}{1+r}$, $r = 0.055$
p	1.5522	relative price of h	sample mean
δ_k	0.1275	depreciation rate of k	in-use depreciation rate
δ_h	0.0487	depreciation rate of h	in-use depreciation rate
α	0.7659	curvature of revenue function	GMM estimation
σ	0.0500	CES elasticity of substitution	$\approx$ Leontief aggregator
a	0.6857	share of k	GMM estimation
ρ_z	0.7077	idiosync. prof.: persistency	GMM estimation
σ_z	0.5716	idiosync. prof.: stand. dev.	GMM estimation

- $a = 0.6857 \Rightarrow \frac{h}{k} = \frac{1-a}{a} \approx 0.4584.$

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Structural Estimation

$$\hat{\Theta}_{smm} = \underset{\Theta}{argmin}(M - \tilde{M}(\Theta))' W (M - \tilde{M}(\Theta))$$

- **Structural parameters:**

Model	Restr. Param.	Est. Param.	Model Description
AC	$\phi_k = \phi_h = +\infty$	γ, F_k, ω, F_h	Asym. Adj. Costs
AC+FC(limit)	$\phi_k = \phi_h = 0$	γ, F_k, ω, F_h	Asym. Adj. Costs, Sym. Pledgeability
AC+FC(sym)	$\phi_k = \phi_h = \phi$	$\gamma, F_k, \omega, F_h, \phi$	Asym. Adj. Costs, Sym. Pledgeability
AC+FC	-	$\gamma, F_k, \omega, F_h, \phi_k, \phi_h$	Asym. Adj. Costs, Asym. Pledgeability

- **Targeted Moments:** $corr(i'_k, i_k), corr(i'_h, i_h), spike^+_k, spike^+_h, \overline{h/k}, med(h/k)$ detail
- **Weighting Matrix:** Weighting matrix = (VCV matrix of data moments)$^{-1}$ detail

Model w/ Asym. Adj. Costs and Sym. Pledgeability

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k	ϕ_h
AC	**0.0068**	**0.0015**	**0.0992**	**0.2541**	$+\infty$	$+\infty$
	(0.0010)	(0.0015)	(0.0278)	(0.0064)		
AC+FC(limit)	**0.0200**	**0.0021**	**0.0144**	**0.3983**	0.0000	0.0000
	(0.0153)	(0.0006)	(0.0094)	(0.0179)		

Table: Moments

	$corr(i'_k, i_k)$	$corr(i'_h, i_h)$	$spike_k^+$	$spike_h^+$	$ave(h/k)$	$med(h/k)$	Dist.
AC	0.0080	0.0293	0.2393	0.1420	0.6951	0.4822	50.80
AC+FC(limit)	0.0832	0.0661	0.1748	0.0978	0.5558	0.4979	419.66
Data	**0.0508**	**0.0281**	**0.3527**	**0.2166**	**0.6549**	**0.4407**	-

Model w/ Asym. Adj. Costs and Sym. Pledgeability

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	γ	F_k	ω	F_h	ϕ_k	ϕ_h
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	(0.0153)	(0.0006)	(0.0094)	(0.0179)		

Table: Moments

	$\overline{h/k}_{Q1}$	$\overline{h/k}_{Q2}$	$\overline{h/k}_{Q3}$	$\overline{h/k}_{Q4}$	$\overline{h/k}_{Q5}$	$skew(h/k)$
AC	1.20	0.65	0.67	0.47	0.48	3.23
AC+FC(limit)	0.55	0.56	0.58	0.58	0.51	1.84
Data	**0.94**	**0.80**	**0.64**	**0.51**	**0.38**	**3.31**

Model w/ Asym. Adj. Costs and Sym. Pledgeability

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k ϕ_h
AC+FC(sym.)	**0.0070**	**0.0013**	**0.0419**	**0.3049**	**2.6737**
	(0.0012)	(0.0005)	(0.0087)	(0.0078)	(0.2053)

Table: Moments

	$corr(i'_k, i_k)$	$corr(i'_h, i_h)$	$spike^+_k$	$spike^+_h$	$ave(h/k)$	$med(h/k)$	Dist.
AC+FC(sym.)	0.0180	0.0502	0.2441	0.1406	0.6826	0.4754	53.09
Data	**0.0508**	**0.0281**	**0.3527**	**0.2166**	**0.6549**	**0.4407**	-

Model w/ Asym. Adj. Costs and Sym. Pledgeability

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k ϕ_h
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	$\overline{h/k}_{Q1}$	$\overline{h/k}_{Q2}$	$\overline{h/k}_{Q3}$	$\overline{h/k}_{Q4}$	$\overline{h/k}_{Q5}$	$skew(h/k)$
AC+FC(sym.)	1.10	0.65	0.66	0.47	0.52	3.45
Data	**0.94**	**0.80**	**0.64**	**0.51**	**0.38**	**3.31**

Model w/ Asym. Adj. Costs and Asym. Pledgeability

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k	ϕ_h
AC+FC	**0.0061**	**0.0029**	**0.0233**	**0.2684**	**2.3283**	**2.5466**
	(0.0097)	(0.0048)	(0.0925)	(0.0425)	(1.3100)	(0.3221)

Table: Moments

	$corr(i'_k, i_k)$	$corr(i'_h, i_h)$	$spike_k^+$	$spike_h^+$	$ave(h/k)$	$med(h/k)$	Dist.
AC+FC	0.0204	0.0269	0.2551	0.1589	0.6603	0.4728	36.09
Data	**0.0508**	**0.0281**	**0.3527**	**0.2166**	**0.6549**	**0.4407**	-

Model w/ Asym. Adj. Costs and Asym. Pledgeability

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k	ϕ_h
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	(0.0097)	(0.0048)	(0.0925)	(0.0425)	(1.3100)	(0.3221)

Table: Moments

	$\overline{h/k}_{Q1}$	$\overline{h/k}_{Q2}$	$\overline{h/k}_{Q3}$	$\overline{h/k}_{Q4}$	$\overline{h/k}_{Q5}$	$skew(h/k)$
AC+FC	1.20	0.62	0.51	0.48	0.47	3.69
Data	**0.94**	**0.80**	**0.64**	**0.51**	**0.38**	**3.31**

Discussion on Results

- Model AC matches the data moments better than model AC+FC(limit).
  - Convex costs are estimated to be higher in model AC.

- Model ACFC matches the targeted moments, as well as the untargeted negative correlation between capital size and the share of real estate in total capital.

Discussion on Results

- Model AC matches the data moments better than model AC+FC(limit).
  - Convex costs are estimated to be higher in model AC.

- Model ACFC matches the targeted moments, as well as the untargeted negative correlation between capital size and the share of real estate in total capital.

- High fixed costs of adjusting h.
  - $F_h = 0.268 \Leftrightarrow$ equivalent to 24% of π on average if positive investment on h.
  - $\Rightarrow$ Variation in asset composition.

- Higher pledgeability of h.
  - RE secures external financing equivalent to 2.55 units of RE.
    Non-RE secures external financing equivalent to 2.33 units of Non-RE.
  - $\Rightarrow$ negative correlation between h/k ratio and capital size
  - upper bounds on the pledgeable values of capital assets

Role of Collateral Constraints

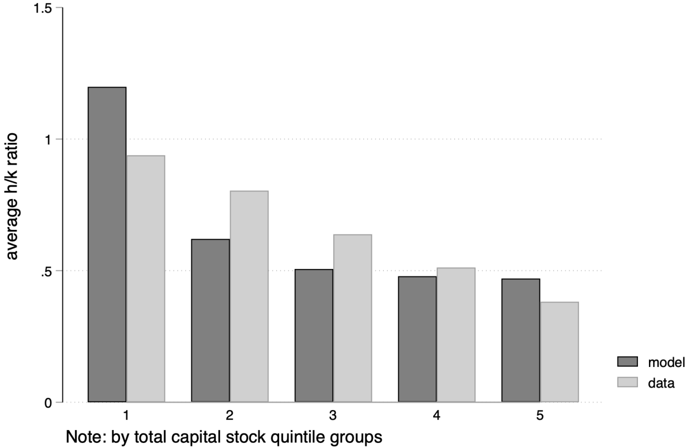
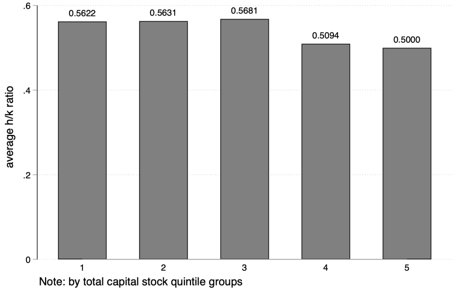
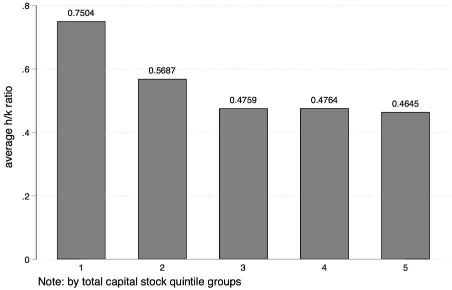


Figure: h/k ratio and Capital Size in Simulation and in Datas

Role of Collateral Constraints



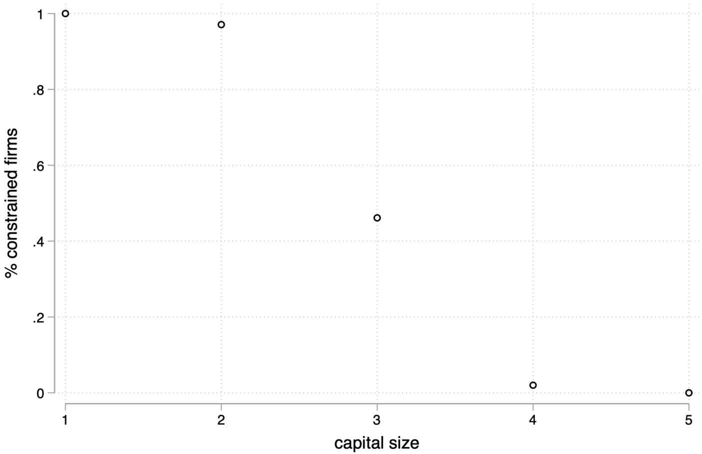
(a) $\phi_k = \phi_h = 0$



(b) $\phi_k = \phi_h = +\infty$

Figure: h/k ratio and Capital Size in Simulation

Binding Constraints



Note: A firm is constrained if its constrained value is less than 97% of its unconstrained value.

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Effect of Frictions

Table: Counterfactual Exercise on Effect of Frictions

model	γ	F_k	ω	F_h	ϕ_k	ϕ_h
baseline	0.006	0.003	0.023	0.268	2.328	2.547
no FC	0.006	0.003	0.023	0.268	$+\infty$	$+\infty$
no FC & no AC	0.006	0.000	0.023	0.000	$+\infty$	$+\infty$

Table: Counterfactual Exercise Results

model	$\overline{h/k}$	$\overline{h/k}, \%$	agg. profitability	agg. revenue	agg. fixed assets
baseline	0.656		1	1	1
no FC	0.549	-16%	1.050	0.992	0.960
no FC & no AC	0.471	-28%	1.032	1.318	1.367

Change in RE Pledgeability

Table: Counterfactual Exercise on Zero RE Pledgeability

model	γ	F_k	ω	F_h	ϕ_k	ϕ_h
baseline	0.006	0.003	0.023	0.268	2.328	2.547
$\phi_h = 0$	0.006	0.003	0.023	0.268	2.328	0.000

Table: Counterfactual Exercise Results

model	$\overline{h/k}$	$\overline{h/k}, \%$	agg. profitability	agg. revenue	agg. fixed assets
baseline	0.656		1	1	1
$\phi_h = 0$	0.596	-9%	0.964	0.997	1.030

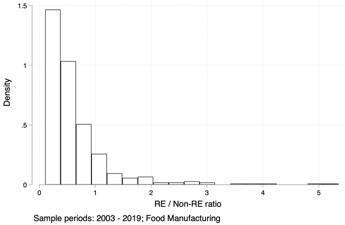
Conclusion

- A characterization of firm capital adjustment dynamics in RE and non-RE assets of Chinese firms.
- High fixed cost in adjusting RE.
- Collateral constraints and heterogenous pledgeability help to explain the larger share of real estate in the asset composition for smaller firms.
- If no financial frictions, the average RE/Non-RE ratio $\downarrow$ by 16%. Aggregate profitability $\uparrow$ by 5%. Aggregate revenue $\downarrow$ by 0.8%.
- If real estate is not pledgeable, average RE/Non-RE ratio $\downarrow$ by 9%. Aggregate profitability $\downarrow$ by 3.6%. Aggregate revenue $\downarrow$ by 0.3%.

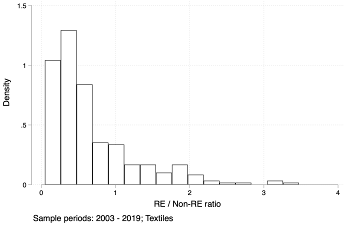
Thank You!

Capital Composition of Chinese Listed Firms, by industry

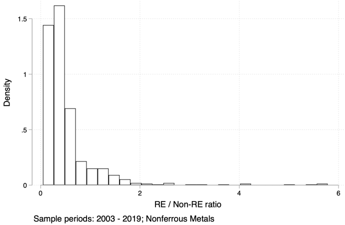
back



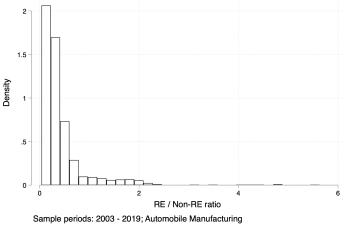
(a) Food Manufacturing



(b) Textiles

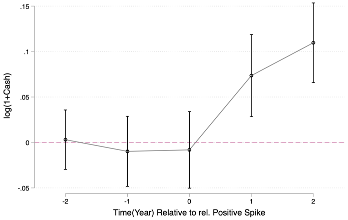


(c) Nonferrous Metals

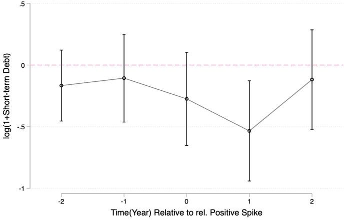


(d) Automobile Manufacturing

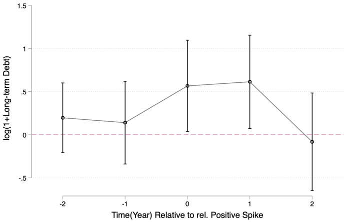
Cash/Debt dynamics around Investment Spikes back



(a) cash and cash equivalent

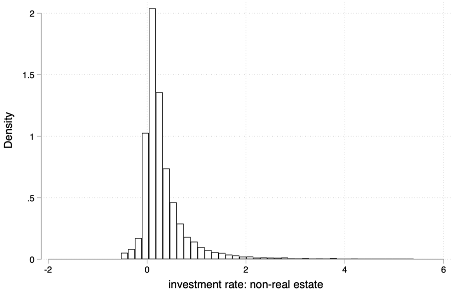


(b) short-term debt

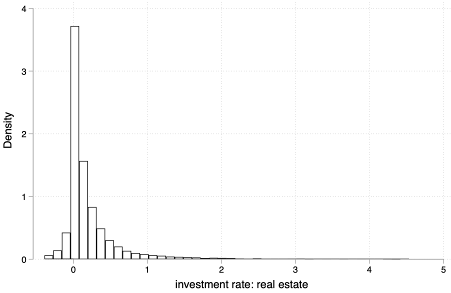


(c) long-term debt

Distribution of Investment Rates



(a) non-real estate capital



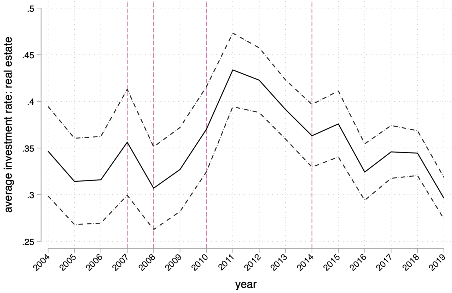
(b) real estate capital

Figure: Distribution of Investment Rates

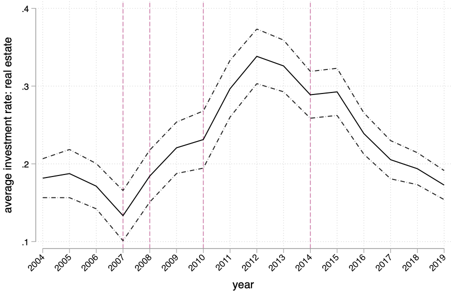
Source: Financial Reports of Listed Companies in China. Based on asset types classified by the author.

back

Trend of Investment Rates



(a) non-real estate capital



(b) real estate capital

Figure: Trend of Investment Rates

Source: Financial Reports of Listed Companies in China. Based on asset types classified by the author.

back

Revenue Function Estimation back

	$\widehat{\rho_z}$	$\widehat{\alpha}$	$\widehat{a}$	$\widehat{\sigma}$	$Dist$
$\sigma = 0.05$	0.7077 (0.011)	0.7659 (0.012)	0.6857 (0.012)	n.a.	327.56
$\sigma = 0.5375$	0.7187 (0.011)	0.7505 (0.012)	0.5968 (0.013)	n.a.	363.91
$\sigma = 1.0250$	0.7345 (0.012)	0.7277 (0.012)	0.5088 (0.023)	n.a.	386.43
$\sigma = 1.5125$	0.7430 (0.012)	0.7188 (0.013)	0.4196 (0.033)	n.a.	394.01
$\sigma = 2.00$	0.9000 (0.008)	0.4092 (0.021)	0.7318 (0.080)	n.a.	421.39

Note: The estimates are obtained with a two-step GMM estimator. The sample is an unbalanced panel with 2092 firms and 17 years (2003-2019).

Revenue Function Estimation back

	$\widehat{\rho_z}$	$\widehat{\alpha}$	$\widehat{a}$	$\widehat{\sigma}$	*Dist*
$\sigma = 0.05$	0.8469 (0.015)	0.6497 (0.032)	0.7255 (0.026)	n.a.	83.55
$\sigma = 0.5375$	0.8495 (0.015)	0.6352 (0.031)	0.6471 (0.030)	n.a.	87.22
$\sigma = 1.0250$	0.8497 (0.015)	0.6350 (0.031)	0.5744 (0.052)	n.a.	87.16
$\sigma = 1.5125$	0.8502 (0.015)	0.6342 (0.031)	0.5082 (0.079)	n.a.	86.96
$\sigma = 2.00$	0.8505 (0.015)	0.6335 (0.031)	0.4448 (0.105)	n.a.	86.86

Note: The estimates are obtained with a two-step GMM estimator. The sample is a balanced panel with 785 firms and 5 years (2015-2019).

Data Moments

Table: Targeted Data Moments

Value	Description	Definition
0.0508	serial correlation of i_k	$corr(i_k', i_k)$
0.0281	serial correlation of i_h	$corr(i_h', i_h)$
0.3527	positive spikes of i_k	$spike_k^+ \equiv Pr(i_k > 30\%)$
0.2166	positive spikes of i_h	$spike_h^+ \equiv Pr(i_h > 30\%)$
0.6549	sample average of h/k	$\overline{h/k}$
0.4407	sample median of h/k	$med(h/k)$

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Weighting Matrix

Table: Weighting Matrix

	$corr(i'_k, i_k)$	$corr(i'_h, i_h)$	$spike_k^+$	$spike_h^+$	$ave(h/k)$	$med(h/k)$
$corr(i'_k, i_k)$	11,122					
$corr(i'_h, i_h)$	-2,141	13,187				
$spike_k^+$	-3,117	-1,773	244,679			
$spike_h^+$	-600	-397	-46,365	188,842		
$ave(h/k)$	819	-502	-6,245	-3,864	23,083	
$med(h/k)$	-1,591	1,153	2,946	4,091	-22,160	36,006

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