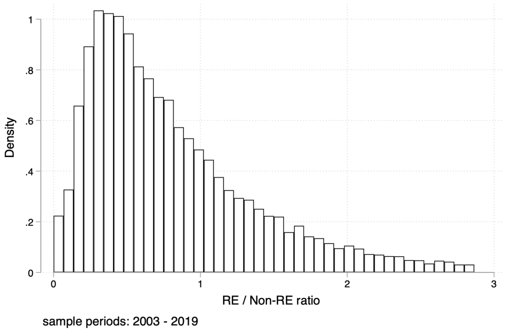
Collateral Constraints and Investment Composition

Chengzi Yi

European University Institute

January 24, 2024

Capital Composition of Chinese Listed Firms

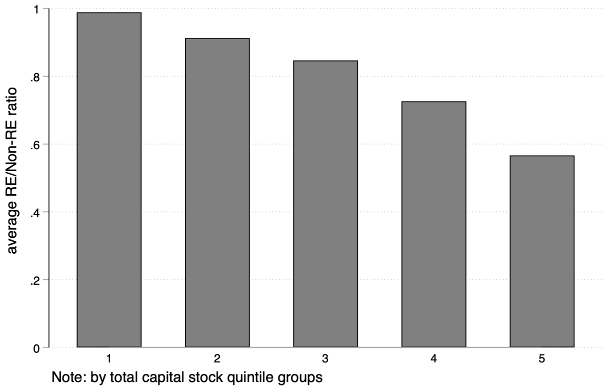


Source: Financial Reports of Listed Companies in China. Based on asset types classified by the author.

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.

Motivation

Investment composition between real estate capital (RE) and non-real estate capital (Non-RE)

- Distinct capital inputs for production.
- Distinct adjustment costs.

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

- Binding collateral constraints $\rightarrow$ capital investment
  (Gan, 2007; Chaney et al., 2012)
- Credit constraints $\rightarrow$ firms' precautionary investment
  (Perez-Orive, 2016; Aghion et al., 2010)

This Paper

- A capital adjustment model with collateral constraints and two capital inputs.
  - Cobb-Douglas aggregator in production
  - Convex and non-convex adjustment costs
  - Pledgeability
- Revenue function and idiosyncratic shock process estimated using GMM.
- Adjustment cost and pledgeability estimated using SMM.
  $\Longrightarrow$ Compare the "Goodness of fit" of the model with and without collateral constraints.

Takeaways

- **Introduction of collateral constraints $\Rightarrow$ Better model fit.**
  - The model generates a RE/Non-RE ratio of 0.7729 on average, close to the observed sample mean of 0.7989.
- **Quantification of the effect of collateral constraints.**
  - By relaxing collateral constraints, the ratio decreases by 33%.
- **Identification of adjustment costs for different assets.**
  - Higher fixed cost of adjusting non-real estate capital.
  - Higher convex cost of adjusting real estate capital.

Literature

- **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.

- **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.

Table of Contents

Model

- 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 $\sigma \to 1$, $(\frac{k}{a})^{a}(\frac{h}{1-a})^{1-a}$.

Model

Cost of adjusting k

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

Cost of adjusting h

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

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...

Model

Cost of adjusting k

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

Cost of adjusting h

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

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...

Model

Cost of adjusting k

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

Cost of adjusting h

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

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...

Model

Extensive Margin

$$V(k,h,z) = max\{V^1(k,h,z), V^2(k,h,z), V^3(k,h,z), V^4(k,h,z)\}$$

- $V^1(k,h,z)$ is the value if adjusting k and h.
- $V^2(k,h,z)$ is the value if only adjusting k.
- $V^3(k,h,z)$ is the value if only adjusting h.
- $V^4(k,h,z)$ is the value of inaction.

Model

Intensive Margin

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

Model

Intensive Margin

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

$$V^2(k,h,z) = \max_{k'>0} \quad \pi(k,h,z) - C(k,k') + \beta \mathbb{E} V(k',h(1-\delta_h),z')$$
$$s.t.\ C(k,k') \leq \pi(k,h,z) + \phi_k k(1-\delta_k) + \phi_h p_h h(1-\delta_h)$$

$$\vdots$$

$$V^4(k,h,z) = \pi(k,h,z) + \beta \mathbb{E} V(k(1-\delta_k), h(1-\delta_h), z')$$

Table of Contents

Data

- Financial Reports of Chinese Listed 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 $\delta_k = 0.145$ and $\delta_h = 0.058$.
  - investment rate: $\frac{i_t^k}{k_t}; \frac{i_t^h}{h_t}$. Distribution
  - variables adjusted for year-fixed effects. Trend

Revenue Function Estimation

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

$$\Downarrow$$

$$log\pi_{it} = \rho_z log\pi_{it-1} + \alpha \cdot a \cdot (logk_{it} - \rho_z logk_{it-1}) + \alpha \cdot (1-a) \cdot (logh_{it} - \rho_z logh_{it-1}) + \xi_{it}$$

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

Table: Revenue Function Parameters

$\widehat{\rho_z}$	$\widehat{\alpha \cdot a}$	$\widehat{\alpha \cdot (1-a)}$
0.7768	0.4601	0.1925
(0.013)	(0.023)	(0.024)

Pre-defined Parameters

	Value	Description	Source
β	0.9479	discount factor	$\frac{1}{1+r}$, $r = 0.055$
σ	1	CES elasticity of substitution	Cobb-Douglas aggregator
p	1.76	relative price of h	sample mean
δ_k	0.145	depreciation rate of k	in-use depreciation rate
δ_h	0.058	depreciation rate of h	in-use depreciation rate
α	0.6525	curvature of revenue function	GMM estimation
a	0.7051	CD share of k	GMM estimation
ρ_z	0.7768	idiosync. prof.: persistency	GMM estimation
σ_z	0.5625	idiosync. prof.: stand. dev.	GMM estimation

- $a = 0.7051 \Rightarrow \frac{1-a}{a} \approx 0.42.$

Pre-defined Parameters

	Value	Description	Source
β	0.9479	discount factor	$\frac{1}{1+r}$, $r = 0.055$
σ	1	CES elasticity of substitution	Cobb-Douglas aggregator
p	1.76	relative price of h	sample mean
δ_k	0.145	depreciation rate of k	in-use depreciation rate
δ_h	0.058	depreciation rate of h	in-use depreciation rate
α	0.6525	curvature of revenue function	GMM estimation
a	0.7051	CD share of k	GMM estimation
ρ_z	0.7768	idiosync. prof.: persistency	GMM estimation
σ_z	0.5625	idiosync. prof.: stand. dev.	GMM estimation

- $a = 0.7051 \Rightarrow \frac{1-a}{a} \approx 0.42.$

Structural Estimation I

Model without Constraints

- $\phi_k = \phi_h = +\infty$.
- Just-identified estimator and over-identified estimator.
  - Parameters: γ, ω, F_k, F_h.
  - Moments: $corr(i'_k, i_k), corr(i'_h, i_h), spike_k^+, spike_h^+, \overline{h/k}, med(h/k)$.
- Identity weighting matrix.

Model without Constraints

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k	ϕ_h
benchmark-JID	0.1192	0.2513	0.0000	0.0358	$+\infty$	$+\infty$
benchmark-OID	0.3000	0.2988	0.2124	0.2973	$+\infty$	$+\infty$

Table: Moments

	$corr(i'_k, i_k)$	$corr(i'_h, i_h)$	$spike_k^+$	$spike_h^+$	$\overline{h/k}$	$med(h/k)$	Distance
benchmark-JID	0.0785	0.0161	0.1197	0.1524	**0.4281**	**0.4125**	5.48E-05
benchmark-OID	0.0950	0.0939	0.1423	0.0597	0.6984	0.5899	0.0282
data	0.0777	0.0182	0.1268	0.1526	0.7989	0.6470	-

Model without Constraints

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k	ϕ_h
benchmark-JID	0.1192	0.2513	0.0000	0.0358	$+\infty$	$+\infty$
benchmark-OID	0.3000	0.2988	0.2124	0.2973	$+\infty$	$+\infty$

Table: Moments

	$corr(i'_k, i_k)$	$corr(i'_h, i_h)$	$spike^+_k$	$spike^+_h$	$\overline{h/k}$	$med(h/k)$	Distance
benchmark-JID	0.0785	0.0161	0.1197	0.1524	**0.4281**	**0.4125**	5.48E-05
benchmark-OID	0.0950	0.0939	0.1423	0.0597	0.6984	0.5899	0.0282
data	0.0777	0.0182	0.1268	0.1526	0.7989	0.6470	-

Model without Constraints

Just-identified Estimator:

- Higher fixed cost of adjusting k.
- Good fit of serial correlations and investment spikes.
- Little variation in asset composition.
- Share of h too low.

Over-identified Estimator:

- (Overly) high convex and non-convex costs for both k and h.

Structural Estimation II

Model with Constraints

- Just-identified estimator
  - Parameters: $\gamma, \omega, F_k, F_h, \phi_k, \phi_h$.
  - Moments: $corr(i'_k, i_k), corr(i'_h, i_h), spike_k^+, spike_h^+, \overline{h/k}, med(h/k)$.
- Compared to **benchmark-OID**.

Model with Constraints

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k	ϕ_h
benchmark-OID	0.3000	0.2988	0.2124	0.2973	$+\infty$	$+\infty$
benchmark-JID	0.1192	0.2513	0.0000	0.0358	$+\infty$	$+\infty$
constrained	0.0874	0.2651	0.2768	0.0654	0.1115	0.1606

Table: Moments

	$corr(i'_k, i_k)$	$corr(i'_h, i_h)$	$spike_k^+$	$spike_h^+$	$\overline{h/k}$	$med(h/k)$	Distance
benchmark-OID	0.0950	0.0939	0.1423	0.0597	0.6984	0.5899	0.0282
constrained	0.0487	0.0124	0.1651	0.1395	0.7729	0.6737	0.0039
data	0.0777	0.0182	0.1268	0.1526	0.7989	0.6470	-

Model with Constraints

Table: Parameter Estimates

	γ	F_k	ω	F_h	ϕ_k	ϕ_h
benchmark-OID	0.3000	0.2988	0.2124	0.2973	$+\infty$	$+\infty$
benchmark-JID	0.1192	0.2513	0.0000	0.0358	$+\infty$	$+\infty$
constrained	0.0874	0.2651	0.2768	0.0654	0.1115	0.1606

Table: Moments

	$corr(i'_k, i_k)$	$corr(i'_h, i_h)$	$spike_k^+$	$spike_h^+$	$\overline{h/k}$	$med(h/k)$	Distance
benchmark-OID	0.0950	0.0939	0.1423	0.0597	0.6984	0.5899	0.0282
constrained	0.0487	0.0124	0.1651	0.1395	0.7729	0.6737	0.0039
data	0.0777	0.0182	0.1268	0.1526	0.7989	0.6470	-

Asset Composition

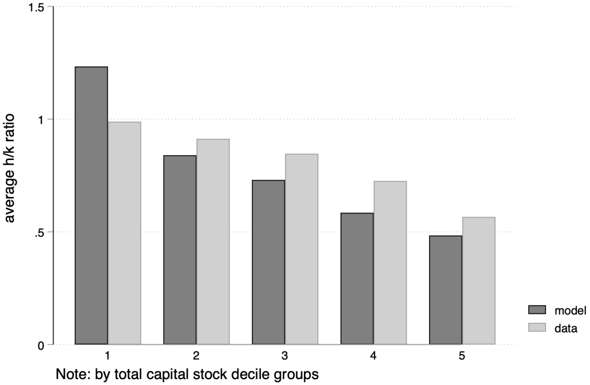


Figure: h/k ratio and capital size

Note: Total capital stock is defined as $k + h$. The observations are grouped into five bins according to the quintiles of total capital stock. The graph plots the average h/k ratio for each group.

Model with Constraints

- Better goodness of fit.
  - Bigger share of real estate as in the data. (targeted)
  - Higher share of real estate for smaller firms. (untargeted)
- $\phi_k = 0.1115$ and $\phi_h = 0.1606$. Collateral Constraints and Data Moments
  - One unit of k (h) allows for external funding equivalent to 0.1115 (0.1606) unit of k (h).
  - Close to 15% in Catherine et al. (2022)
- Higher fixed cost of adjusting k.
- Higher quadratic cost of adjusting h.

Table of Contents

Decomposition of the Effects of Frictions

	baseline	no fin.	no fin. & no fixed.
$\overline{h/k}$	0.77	0.52	0.49
$\overline{h/k}$, %	100%	-33%	-37%
$p_{25}(h/k)$	0.46	0.38	0.40
$p_{50}(h/k)$	0.68	0.48	0.44
$p_{75}(h/k)$	0.98	0.63	0.54
$sd(\pi/K)$	0.19	0.18	0.14

Conclusion

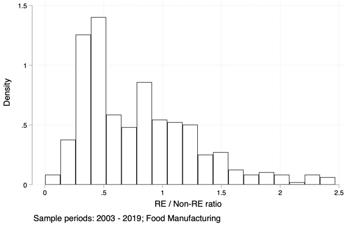
- A characterization of firm capital adjustment dynamics in RE and non-RE assets of Chinese firms.
- Collateral constraints help to explain the high proportion of real estate in the capital stock and the larger share of real estate in the asset composition for smaller firms.
- If no financial frictions, the RE/Non-RE ratio decreases by 33% (0.52 vesus 0.77).
- Higher fixed cost in adjusting non-RE. Higher quadratic cost in adjusting RE.

Limitations and Next Steps

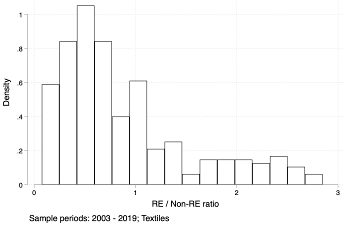
- Strong assumption of Cobb-Douglas aggregation technology.
  $\Rightarrow$ other forms of aggregation function.
- Effect of overall collateral tightness and relative pledgeability.
  $\Rightarrow$ better formation of the collateral constraints.
- No dynamic debt/cash decision.
  $\Rightarrow$ add debt as an endogenous state variable.

Thank you!

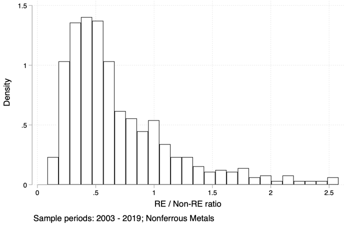
Capital Composition of Chinese Listed Firms, by industry back



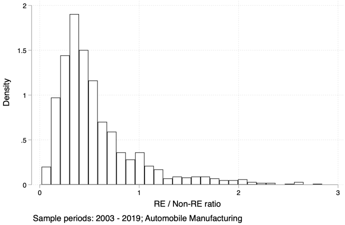
(a) Food Manufacturing



(b) Textiles

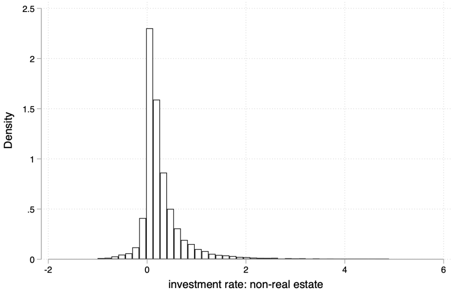


(c) Nonferrous Metals

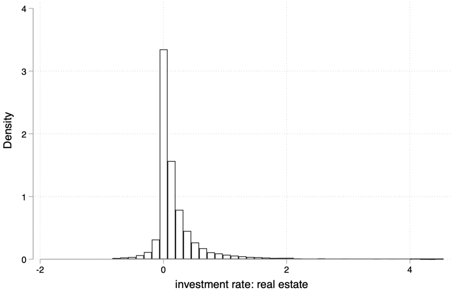


(d) Automobile Manufacturing

Distribution of Investment Rates



(a) non-real estate capital



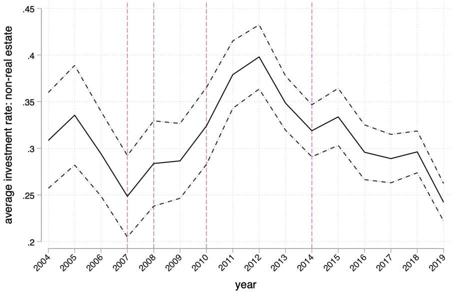
(b) real estate capital

Figure: Distribution of Investment Rates

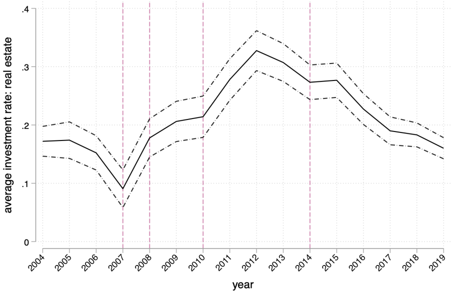
Source: Financial Reports of Listed Companies in China. Based on asset types classified by the author.

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

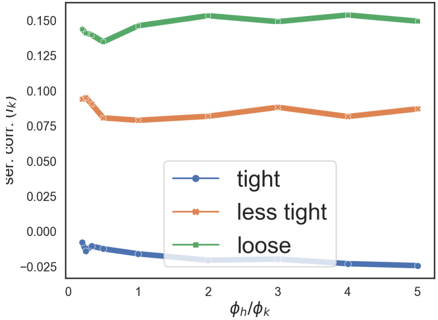
Collateral Constraints and Data Moments: Illustrative Example

- Other parameters symmetric between k and h:

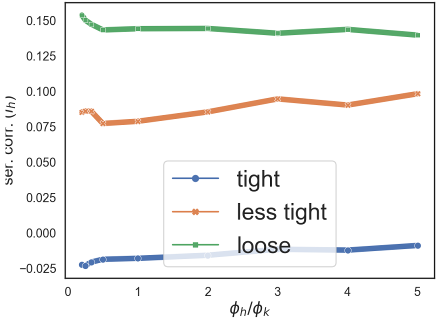
δ_k	δ_h	p_h	a	γ	F_k	ω	F_h
0.1	0.1	1	0.5	0.2	0.17	0.2	0.17

- Constraint slackness ($\phi_k + \phi_h$): $[0.5, 1, 1.5]$.
- Relative pledgeability ($\frac{\phi_h}{\phi_k}$): $[\frac{1}{5}, \frac{1}{4}, \frac{1}{3}, \frac{1}{2}, 1, 2, 3, 4, 5]$.

Collateral Constraints and Data Moments

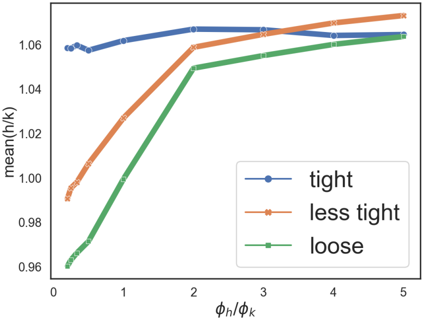


(a) Autocorrelation of i_k

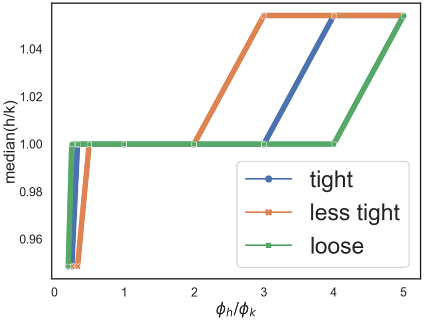


(b) Autocorrelation of i_h

Collateral Constraints and Data Moments



(a) Average h/k



(b) Median h/k

back