# Collateral Booms and Information Depletion

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June $4^{\text{th}}$, 2019

# Introduction

- Fluctuations in credit are common (more so in recent years).
  Claessens et al. 2011, Mendoza and Terrones 2012, Bakker et al. 2012.
- Good things happen during credit booms...
  - Asset prices, GDP growth and investment are higher than in normal times.
- Yet, credit booms are often viewed with suspicion...
  - Fall in lending standards/information quality on borrowers,
    Asea and Blomberg 1998; Keys et al. 2010; Becker et al. 2018.
  - Rise in factor misallocation,
    Gopinath et al. 2017; Garcia-Santana et al. 2017; Doerr 2018.
  - Often followed by crises and low growth.
    Schularick and Taylor 2012.

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        - Projects are heterogeneous in "quality," low or high.
        - Low quality projects allow entrepreneurs to extract rents.
    - Lenders have two ways of protecting themselves:
        - *Collateralization*: ask entrepreneurs to put up assets as collateral.
        - *Screening*: produce costly but durable information about project quality.
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- We provide new empirical evidence in support of the model's main predictions using US firm-level data.

# The Model

# Environment, preferences and endowments

- Time is infinite, $t = 0, 1, \ldots.$ Small-open economy.
- OLG of agents, of constant size and two-period lifetimes.
- Entrepreneurs and savers, unit mass each, with preferences

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  - Supply one unit of labor when young, and receive wage $w_t$.
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- Savers:
  - Supply one unit of labor when young, and receive wage $w_t$.
  - Save abroad or lend to entrepreneurs at (expected) gross return $\rho$.
- Entrepreneurs:
  - Endowed with collateral with value $q_t$ at time $t$ (e.g. land, real estate).
  - When young: purchase and invest in capital.
    - Finance these activities by borrowing from lenders.
  - When old: hire labor to produce consumption goods.

# Technology

- Investment: one consumption good at $t \rightarrow$ one unit of capital at $t+1$.
  - Two types of capital, $\theta \in \{L, H\}$, but more on this shortly...
  - A unit's type persists throughout its life.
  - Capital depreciates at rate $\delta$ and is reversible.
- Production: Cobb-Douglas technology

$$F_t(k_{it}, l_{it}) = A_t \cdot k_{it}^{\alpha} \cdot l_{it}^{1-\alpha},$$

where $A_t$ is aggregate productivity, $k_{it}$ are units of *effective* capital and $l_{it}$ are units of labor.

# Quality of projects

- $L$-type suffers from an agency problem.
  - Entrepreneur can run away with all the resources generated by it.
  - Thus, $L$-type capital is effectively less pledgeable.
- Baseline: $H$- and $L$- types of capital are equally productive.
  - Later, also productivity differences $\rightarrow$ factor "misallocation."

# Screening and information production

- Ex-ante, the quality of each unit of investment is uncertain.
  - $\mathbb{P}(\theta = H) = \mu \in (0,1)$ and quality iid across units.
- Before investing, each unit can be "screened" at cost $\psi_t$, in which case its type is publicly revealed.
- Let $s_t$ denote the units screened in aggregate at $t$, then we assume that $\psi_t = \psi(s_t)$ with properties $\psi(0) = 0$ and $\psi'(\cdot) > 0$.
  - Micro-foundation: screening services and credit provided by competitive intermediary sector that hires experts (e.g., savers) who have heterogeneous screening costs.
- Past performance of a unit is not publicly observable.

# Markets

Notation: $\theta$-type capital $k_{it}^{\theta}$, unscreened capital $k_{it}^{\mu}$, and effective capital $k_{it} = k_{it}^{H} + k_{it}^{L} + k_{it}^{\mu}$. The aggregate capital stock is $k_t = \int_i k_{it} di$.

Marginal product of capital: $r_t = A_t \alpha k_t^{\alpha-1}$.

- Labor market:
  - Old entrepreneurs hire young savers at market wage $w_t$.
- Capital market:
  - Old entrepreneurs sell capital to young at prices $p_t^j$ for $j \in \{H, L, \mu\}$.
  - Since capital is reversible, the old strictly prefer to sell only if $p_t^j > 1$.
- Credit market:
  - Young entrepreneur borrows from lenders $f_{it}$ and invests $q_t + f_{it}$.
  - Contracts are state-contingent, but there are (endogenous) constraints:

$$R_{it+1} f_{it} \leq \left(r_{t+1} + (1-\delta)\max\{p_{t+1}^{H}, 1\}\right) k_{it+1}^{H} + \left(r_{t+1} + (1-\delta)\max\{p_{t+1}^{\mu}, 1\}\right) \mu k_{it+1}^{\mu}.$$

# Equilibrium prices

- Labor market clearing:

$$w_t = A_t \left(1 - \alpha\right) k_t^{\alpha}.$$

- Credit market clearing:

$$E_t\{R_{it+1}\} = \rho.$$

- Capital market clearing:

$$p_t^H = 1 + \frac{\psi(s_t)}{\mu} \geq 1 = p_t^{\mu} = p_t^L.$$

  - Intuition: price equals production cost.

# Equilibrium dynamics

Given $\{k_0^H, k_0^L, k_0^\mu\}$ and process $\{q_t, A_t\}_{t\geq 0}$, equilibrium is characterized by:

- Zero expected profits on $H$-type investment:

$$1 + \frac{\psi(s_t)}{\mu} = \frac{E_t\left\{r_{t+1} + (1-\delta)\left(1 + \frac{\psi(s_{t+1})}{\mu}\right)\right\}}{\rho},$$

- $H$-type investment: $s_t = \max\left\{0, \frac{k_{t+1}^H - (1-\delta)k_t^H}{\mu}\right\}$,
- No $L$-type investment: $k_{t+1}^L = 0$.
- Unscreened investment constrained by collateral:

$$k_{t+1}^\mu = \min\left\{\frac{\rho}{\rho - \mu E_t\{r_{t+1} + 1 - \delta\}} \cdot q_t,\ k_{t+1}^*\right\},$$

where $r_{t+1} = A_{t+1}\alpha(k_{t+1}^H + k_{t+1}^\mu)^{\alpha-1}$.

# Collateral booms and busts

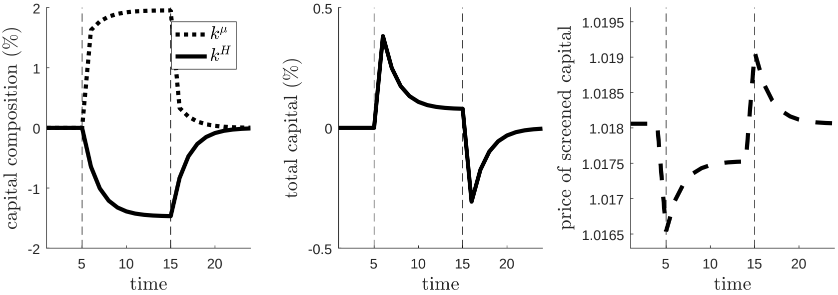
# Boom-bust episodes

We consider the following experiments:

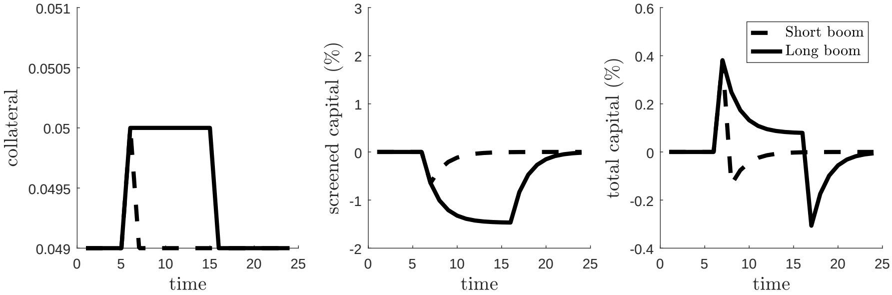
- Collateral $q$ takes values in $\{\underline{q}, \overline{q}\}$ with $\mathbb{P}(q_{t+1} = \overline{q} | q_t = \underline{q}) \in (0, \frac{1}{2})$ and $\mathbb{P}(q_{t+1} = \underline{q} | q_t = \overline{q}) \in (0, \frac{1}{2})$.
- For comparison, productivity $A$ takes values in $\{\underline{A}, \overline{A}\}$ with $\mathbb{P}(A_{t+1} = \overline{A} | A_t = \underline{A}) \in (0, \frac{1}{2})$ and $\mathbb{P}(A_{t+1} = \underline{A} | A_t = \overline{A}) \in (0, \frac{1}{2})$.

Suppose throughout that parameters are such that borrowing constraints bind $\forall t$.

# Collateral boom-bust episode

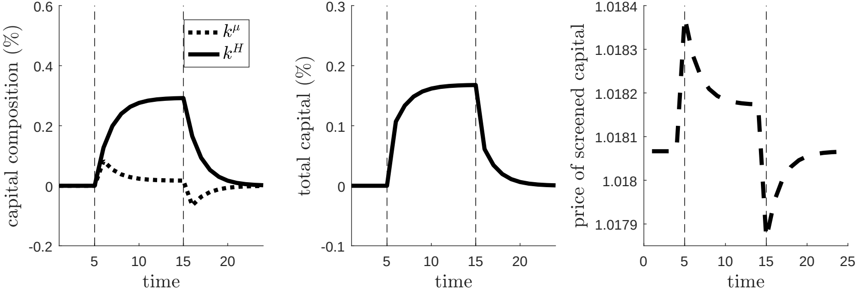


# Longer booms → larger busts



# Source of the boom matters

## Productivity boom-bust episode



# Normative properties of equilibrium

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- Too little information production? No...
- Consider planner who maximizes discounted consumption subject to same information friction/borrowing constraint as market.
- Planner optimality condition:

$$1+\frac{\psi(s_t)}{\mu}=\frac{E_t\left\{A_{t+1}\alpha k_{t+1}^{\alpha-1}+(1-\delta)\left(1+\frac{\psi(s_{t+1})}{\mu}\right)\right\}}{\rho}$$
$$+\underbrace{\left(\frac{E_t\left\{A_{t+1}\alpha k_{t+1}^{\alpha-1}+1-\delta\right\}}{\rho}-1\right)\cdot\frac{\partial k^{\mu}(k_{t+1}^{H},q_t,A_t)}{\partial k_{t+1}^{H}}}_{\text{Distortion}}$$

- Source of inefficiency: by screening more, entrepreneurs depress MPK, tightening borrowing constraints and crowding out unscreened investment.
- Implementation: can correct inefficiency through Pigouvian taxes on screened investment, with revenues rebated lump sum to savers.

# Additional considerations

1. Interpretation through project creation and screening:
   - Each project employs labor and at most $\bar{k}$ units of capital.
   - Projects become obsolete at rate $\gamma$; capital depreciates at rate $\delta$.
2. Credit booms and factor "misallocation":
   - Assume that $H$-type projects are also more productive.
   - TFP dispersion across projects increases in $q_t$ if starting with small $q_t$.
3. Interpretation of fluctuations in $q_t$:
   - Activity organized within firms $=$ collection of projects.
   - Rational bubbles on firms randomly appear and burst.
4. Irreversibilities and "fire-sales":
   - Assume that capital can be converted to $\chi \in (0,1)$ units of consumption.
   - During the bust, some of the effect is absorbed by project prices.

# Conclusions

- Model of Collateral Booms and Information Depletion.
    - Rising collateral values boost investment and economic activity,
    - But reallocate investment towards less information-intensive activities:
        - Lower incentives to produce information.
        - Information depletion over time...
    - Longer booms → more info depletion → larger busts.
- Source of the credit boom matters.
    - Productivity-driven booms do not deplete information.
- Normative aspects of credit booms:
    - "Misallocation" may increase during booms, but save on screening costs.
    - If anything, due to pecuniary externalities, there is too much information!
- We provide new empirical evidence in support of the model's main predictions using US firm-level data.

# Related literature

- Credit booms and lending standards: Manove et al. (2011), Ruckes (2004), Martin (2005), Dell'Ariccia and Marquez (2006), Gorton and He (2008), Favara (2012), Petriconi (2015), Krishnamurthy and Muir (2017).
- Information production in macro: Van Nieuwerburgh and Veldkamp (2006), Ordoñez (2013), Gorton and Ordoñez (2014, 2016), Fajgelbaum et al. (2017), Straub and Ulbricht (2017).
- Collateral and investment: Peek and Rosengreen (2000), Gan (2007), Chaney et al. (2012).
- Financial frictions and investment composition: Matsuyama (2007), Diamond et al. (2018).
- Pecuniary externalities: Caballero and Krishnamurthy (2003), Lorenzoni (2008), Dávila and Korinek (2017).

# Appendix

# Testable implications

1. Investment is increasing in collateral values.
2. Share of unscreened investment is increasing in collateral values.
3. Collateral bust is followed by fall in investment, and more so the larger is the share of unscreened investment in the boom.

# Empirical strategy

Two challenges:

1. Identify shocks to outside collateral:
   - Build on Chaney et al. (2012): effect of real estate prices on investment.
   - Extend sample: COMPUSTAT firms 1993-2012.
   - Real estate assets in 1993: infer market value using local real estate inflation.
2. Measure unscreened investment: proxy firm-level information with
   - Bid-ask spread on firm stock,
   - Ratio of intangible to tangible fixed assets, and
   - Analyst coverage.

   Implicit mapping: high-info firms $\approx$ screened investment; low-info firms $\approx$ unscreened investment.

# Firm-level regressions

1. How does the value of real estate affect investment by firm $i$ in location $k$?

$$I_{it} = \alpha_i + \delta_t + \beta \cdot RE_{it} + \gamma \cdot P_{kt} + controls_{it} + \varepsilon_{it}$$

2. How is this effect correlated with firm level information, e.g. spread?

$$I_{it} = \alpha_i + \delta_t + \beta_1 \cdot Spread_{it} + \beta_2 \cdot RE_{it} + \\ + \beta_3 \cdot RE_{it} \cdot Spread_{it} + \gamma \cdot P_{kt} + controls_{it} + \varepsilon_{it}$$

# Empirical findings

## Dependent variable $I_{it}$

Table 3: Investment and collateral

| VARIABLES | (1) OLS | (2) OLS | (3) OLS | (4) OLS | (5) IV |
|---|---|---|---|---|---|
| RE Value (State Prices) | 0.0622*** | 0.0563*** | 0.0478*** | | |
| | (0.00345) | (0.00361) | (0.00349) | | |
| State Prices | -0.0999* | -0.367 | -0.142 | | |
| | (0.0529) | (0.305) | (0.347) | | |
| Cash | | | 0.0253*** | 0.0262*** | 0.0269*** |
| | | | (0.00241) | (0.00276) | (0.00293) |
| Market/Book | | | 0.0577*** | 0.0604*** | 0.0605*** |
| | | | (0.00282) | (0.00295) | (0.00318) |
| RE Value (MSA Prices) | | | | 0.0461*** | 0.0506*** |
| | | | | (0.00395) | (0.00752) |
| MSA Prices | | | | -0.465 | 0.447 |
| | | | | (1.061) | (0.375) |
| Initial Controls x State Prices | No | Yes | Yes | No | No |
| Initial Controls x MSA Prices | No | No | No | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes |
| Observations | 34 986 | 34 746 | 31 351 | 26 596 | 22 901 |
| Adjusted R-squared | 0.270 | 0.281 | 0.311 | 0.320 | 0.322 |

# Empirical findings

## Dependent variable $I_{it}$

Table 4: Investment, collateral and information

| VARIABLES | (1) OLS | (2) OLS | (3) OLS | (4) OLS | (5) IV |
|---|---|---|---|---|---|
| RE Value (State Prices) | 0.0617*** | 0.0474*** | 0.0414*** | | |
| | (0.00373) | (0.00403) | (0.00405) | | |
| Spread | -0.0286*** | -0.0321*** | -0.0209*** | -0.0214*** | -0.0216*** |
| | (0.00182) | (0.00183) | (0.00173) | (0.00204) | (0.00227) |
| RE Value (State Prices) x Spread | 0.00303*** | 0.00438*** | 0.00280*** | | |
| | (0.000712) | (0.000649) | (0.000708) | | |
| State Prices | -0.204*** | -1.052** | -0.802* | | |
| | (0.0605) | (0.452) | (0.453) | | |
| Cash | | | 0.0256*** | 0.0262*** | 0.0268*** |
| | | | (0.00282) | (0.00324) | (0.00343) |
| Market/Book | | | 0.0641*** | 0.0645*** | 0.0638*** |
| | | | (0.00293) | (0.00319) | (0.00346) |
| RE Value (MSA Prices) | | | | 0.0414*** | 0.0462*** |
| | | | | (0.00438) | (0.00525) |
| RE Value (MSA Prices) x Spread | | | | 0.00280*** | 0.00280*** |
| | | | | (0.000926) | (0.00104) |
| MSA Prices | | | | -1.644 | 0.294 |
| | | | | (1.066) | (0.351) |
| Initial Controls x State Prices | No | Yes | Yes | No | No |
| Initial Controls x MSA Prices | No | No | No | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes |
| Observations | 28 370 | 28 256 | 26 535 | 22 568 | 19 448 |
| Adjusted R-squared | 0.349 | 0.363 | 0.391 | 0.396 | 0.392 |

# Aggregate regressions

1. Does high-spread investment in region $k$ increase when the value of real estate increases?

$$\left(\frac{I^{HS}}{I}\right)_{kt} = \alpha_k + \delta_t + \beta \cdot RE_{kt} + \gamma \cdot P_{kt} + \nu_{kt}$$

2. Does the allocation of investment during boom years (2001-2006) affect investment in the bust (2007-2012)?

$$I_{kt} = \alpha_k + \delta_t + \beta_1 \cdot RE_{kt} + \beta_2 \cdot RE_{kt} \cdot \left(\Delta \frac{I^{HS}}{I}\right)_k^{boom} + \gamma \cdot P_{kt} + \nu_{kt}$$

# Empirical findings

## Dependent variable $\left(\frac{I_{HS}}{I}\right)_{kt}$

Table 6: Investment, collateral and information: aggregate results

| VARIABLES | (1) Aggregate | (2) Boom years (2001-2006) |
|---|---|---|
| RE Value (State Prices) at State Level | 0.0308** | 0.0623** |
| | (0.0134) | (0.0301) |
| State Prices | -4.454 | -8.724 |
| | (2.801) | (5.443) |
| Year FE | Yes | Yes |
| State FE | Yes | Yes |
| Observations | 900 | 190 |
| R-squared | 0.110 | 0.213 |

# Empirical findings

## Dependent variable $I_{kt}$

Table 7: Investment, collateral and information: aggregate results during busts

| VARIABLES | (1)<br>Bust years (2007-2012) |
|---|---|
| Δ Investment Ratio during Boom at State Level x RE Value (State Prices) at State Level | 0.293*** |
| | (0.0863) |
| RE Value (State Prices) at State Level | 0.0649*** |
| | (0.0199) |
| State Prices | 0.00679 |
| | (0.0942) |
| Year FE | Yes |
| State FE | Yes |
| Observations | 216 |
| R-squared | 0.707 |

# Additional findings

Table 1: Summary statistics

| | Mean | Median | SD | 25th percentile | 75th percentile | Obs. |
|---|---|---|---|---|---|---|
| Firm-level data | | | | | | |
| Investment | 0.33 | 0.20 | 0.38 | 0.11 | 0.38 | 34 986 |
| Cash | 0.04 | 0.26 | 1.78 | -0.09 | 0.63 | 35 204 |
| Market / Book | 2.16 | 1.52 | 1.76 | 1.10 | 2.42 | 32 512 |
| Spread | 2.26 | 1.36 | 3.07 | 0.77 | 2.56 | 28 643 |
| Analysts | 7.93 | 5.00 | 7.46 | 2.00 | 11.00 | 19 921 |
| Intangibility | 0.51 | 0.35 | 0.62 | 0.16 | 0.64 | 31 167 |
| RE Value (State Prices) | 0.89 | 0.26 | 1.44 | 0.00 | 1.14 | 35 430 |
| RE Value (MSA Prices) | 0.88 | 0.26 | 1.42 | 0.00 | 1.13 | 34 892 |
| State Prices | 0.29 | 0.24 | 0.12 | 0.20 | 0.33 | 35 430 |
| MSA Prices | 0.14 | 0.12 | 0.05 | 0.10 | 0.17 | 34 907 |
| Housing Supply Elasticity | 1.17 | 0.90 | 0.67 | 0.65 | 1.42 | 30 753 |
| Initial firm level data (1993) | | | | | | |
| Age | 8.09 | 8.00 | 4.66 | 3.00 | 13.00 | 2 855 |
| ROA | -0.01 | 0.07 | 0.25 | -0.04 | 0.12 | 2 844 |
| Log(Asset) | 4.05 | 3.96 | 2.19 | 2.58 | 5.46 | 2 852 |

# Additional findings

## Dependent variable $P_{kt}$

Table 2: First-stage regression: the impact of local housing supply elasticity on housing prices

| VARIABLES | (1) MSA Prices | (2) MSA Prices |
|---|---|---|
| Housing supply elasticity | 0.00990*** | |
| | (0.00274) | |
| First quartile of elasticity | | -0.0225*** |
| | | (0.00682) |
| Second quartile of elasticity | | -0.00548 |
| | | (0.00751) |
| Third quartile of elasticity | | 0.00141 |
| | | (0.00744) |
| Year FE | Yes | Yes |
| MSA FE | Yes | Yes |
| Observations | 2 232 | 2 232 |
| R-squared | 0.892 | 0.893 |

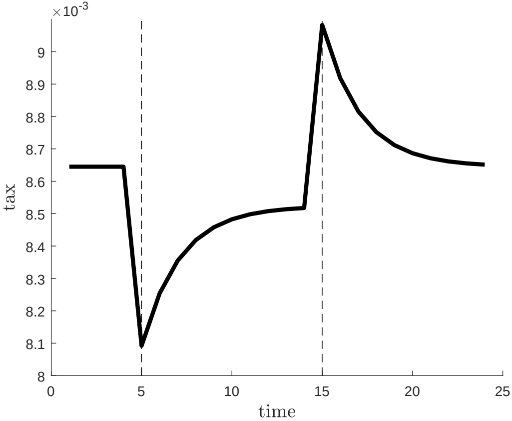
# Additional findings

## Dependent variable $I_{it}$

Table 5: Investment, collateral and information: alternative proxies

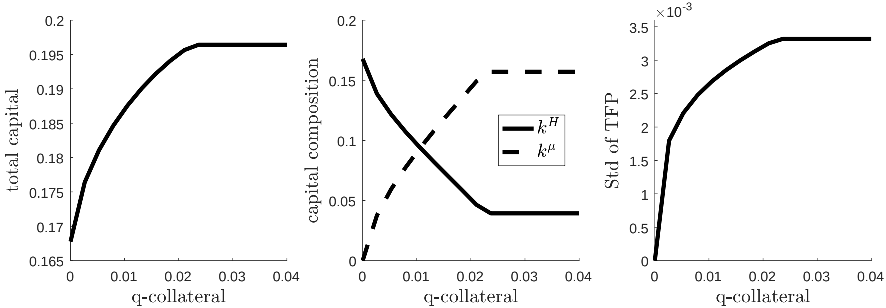
| VARIABLES | (1) OLS | (2) OLS | (3) IV | (4) OLS | (5) OLS | (6) IV |
|---|---|---|---|---|---|---|
| RE Value (State Prices) | 0.0526*** | | | 0.0365*** | | |
| | (0.00779) | | | (0.00432) | | |
| RE Value (MSA Prices) | | 0.0510*** | 0.0598*** | | 0.0346*** | 0.0400*** |
| | | (0.00835) | (0.00982) | | (0.0048) | (0.00569) |
| Analysts | 0.0238*** | 0.0294*** | 0.0300*** | | | |
| | (0.00818) | (0.00846) | (0.00941) | | | |
| RE Value (State Prices) x Analysts | -0.00704** | | | | | |
| | (0.00349) | | | | | |
| RE Value (MSA Prices) x Analysts | | -0.00721** | -0.00949** | | | |
| | | (0.00364) | (0.00396) | | | |
| Intangibility | | | | -0.00359 | -0.00419 | -0.00604 |
| | | | | (0.00491) | (0.00531) | (0.00551) |
| RE Value (State Prices) x Intangibility | | | | 0.00546** | | |
| | | | | (0.00249) | | |
| RE Value (MSA Prices) x Intangibility | | | | | 0.00609** | 0.00673** |
| | | | | | (0.00263) | (0.0028) |
| State Prices | -2.071*** | | | -1.075 | | |
| | (0.785) | | | (0.983) | | |
| MSA Prices | | -2.573 | 0.41 | | -0.648 | 0.854 |
| | | (2.359) | (0.532) | | (2.646) | (0.541) |
| Cash | 0.0313*** | 0.0308*** | 0.0303*** | 0.0277*** | 0.0287*** | 0.0296*** |
| | (0.00442) | (0.00486) | (0.00521) | (0.00304) | (0.00337) | (0.00355) |
| Market/Book | 0.0649*** | 0.0666*** | 0.0665*** | 0.0621*** | 0.0644*** | 0.0644*** |
| | (0.00388) | (0.00395) | (0.00426) | (0.00311) | (0.00325) | (0.00351) |
| Initial Controls x State Prices | Yes | No | No | Yes | No | No |
| Initial Controls x MSA Prices | No | Yes | Yes | No | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 17 051 | 14 517 | 12 432 | 22 436 | 19 134 | 16 510 |
| Adjusted R-squared | 0.452 | 0.469 | 0.471 | 0.371 | 0.379 | 0.380 |

# Pigouvian tax over a collateral-driven boom-bust cycle



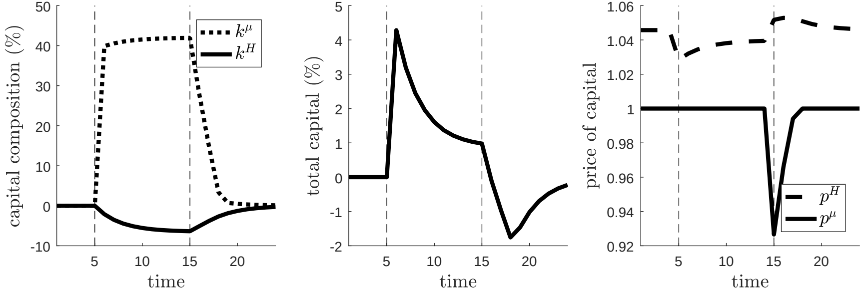
# Collateral booms and misallocation

Here, $\delta = 1$ and $k_t = k_t^H + \lambda k_t^L + (\mu + (1-\mu)\lambda) k_t^\mu$ for $\lambda \in (0, 1)$



# Irreversibilities and "fire-sales"

## Each unit of capital can be converted into $\chi = 0.9$ units of consumption



# Micro-foundation for screening cost

Each period:

- Many banks, provide loans and screening services to entrepreneurs.
- Hire experts (e.g. savers) in a competitive market to do the screening.
  - Each expert can screen at most $n$ projects at cost $c$ per project.
  - $F(\cdot)$ is the distribution of costs in the population of experts, which is continuous with support $[0, \infty)$.
- Let $s$ be the measure of projects screened, then the market clearing expert wage is given by $\psi \geq 0$ such that $s = n \cdot F(\psi)$.
  - Defines map $\psi(\cdot)$ with properties $\psi(0) = 0$ and $\psi'(\cdot) > 0$.
- $\psi(s)$ is the marginal cost and $\int_0^s \psi(x)dx$ is the total cost of screening.

# Normative properties of equilibrium

- The social planner's objective is to maximize:

$$E_0 \sum_{t=0}^{\infty} \rho^{-t} C_t,$$

  which is equivalent to p.v. of social welfare with relative weight $\rho$.
- Set $\rho > 1$ so that the economy is dynamically efficient.
- Information friction: needs to screen to invest in $H$-type capital.
- Financial friction: unscreened investment must be collateralized by $q$.
- Assume parameters are such that borrowing constraints bind for the planner.

# Normative properties of equilibrium

- Formally, the planner's problem is:

$$V(k_t^H, k_t^\mu, q_t, A_t) = \max_{s_t}\{Ak_t^\alpha + (1-\delta)k_t - k_{t+1} - \int_0^{s_t}\psi(x)dx + q_t$$
$$+\rho^{-1}E_tV(k_{t+1}^H, k_{t+1}^\mu, q_{t+1}, A_{t+1})\}$$

where $k_t = k_t^H + k_t^\mu$, subject to:

$$s_t = \max\left\{0, \frac{k_{t+1}^H - (1-\delta)k_t^H}{\mu}\right\},$$
$$k_{t+1}^\mu = \frac{\rho}{\rho - \mu E_t\{A_{t+1}\alpha(k_{t+1}^H + k_{t+1}^\mu)^{\alpha-1} + 1 - \delta\}} \cdot q_t.$$

- From borrowing constraint, $k_{t+1}^\mu = k^\mu(k_{t+1}^H, q_t, A_t)$ is decreasing in $k_{t+1}^H$.