Inefficient Investment Waves

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Investment Waves

- supply of financing is procyclical
  - in booms: more projects are financed $\implies$ high investment, low returns
  - in recessions: less projects are financed $\implies$ low investment, high returns
- two possible contexts: aggregate cycles/industry cycles
Aggregate Investment Waves: Corporate loans/bonds
Inefficient Investment Waves

- Do investment waves arise by simple financing frictions (without persistent shocks in technology)?
- Are these investment waves (constrained) inefficient?
- If yes, too much investment in booms, too little investment in recessions or both?
- Should the government intervene in booms/recessions or both?
In this paper, analytically tractable dynamic stochastic model of trade and investment to show:

- Aggregate constraint on available capital ⇒ (constrained) efficient investment waves

- Unverifiable idiosyncratic investment-opportunities ⇒ (often) two-sided inefficiency
  - in booms: too much investment in productive technology, too little cash holding
  - in recessions: too little investment, too much liquidity hoarding

- Were government intervene only in the recession
  - makes over investment in booms worse
  - even if effective, might make everyone worse off

- Applications: (1) housing cycle, (2) industry cycles, (3) financial development and growth volatility
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A Simplified 2-Period Example: Setting

- ex ante identical agents with 1 capital ($K$), $c$ cash ($C$)
- period 0, investment: agent $i$ can convert 2 units of cash to a unit of capital or 2 units of capital to a unit of cash
- period 1: shocks and trade
  - half agents can produce 3 units of consumption from each unit of capital,
  - other half can turn each unit of cash to 3 units of consumption (through a new investment opportunity)
  - agents trade capital at price $p$, and then consume
• individual’s problem

\[
\max_{K^i, C^i} \frac{1}{2} \left( K^i + \frac{C^i}{p} \right)^3 + \frac{1}{2} \left( K^i p + C^i \right)^3
\]

subject to investment technology

• equilibrium period 1 price \( p = \frac{C}{K} \). Ex post efficient allocation
A Simplified 2-Period Example: Technology

\[ |\text{slope}| = 1/2 \]

\[ |\text{slope}| = 2 \]
A Simplified 2-Period Example: Social Optimum

\[ \max_{K,C} \left( \frac{3}{2} \left( K + \frac{C}{C/K} \right) + \frac{3}{2} \left( C + \frac{K}{K} \right) \right) = 3(K + C) \]
A Simplified 2-Period Example: Market Solution I.

\[ \max_{K, C} \frac{3}{2} \left( K + \frac{C}{C/K} \right) + \frac{3}{2} \left( C + \frac{K C}{K} \right) = 3(K + C) \]

\[ \max_{K_i, C_i} \frac{R}{2} \left( K_i + \frac{C_i}{p} \right) + \frac{u}{2} \left( C_i + K_i p \right) \]

\[ MRS_i = \frac{(1/2)(3+p^3)}{(1/2)((1/p)^3+3)} = p \]
A Simplified 2-Period Example: Market Solution II.

\[ \text{MRS}^i = \frac{p}{C/K} = 2 \]

Market solution: Overinvestment in \( K \)

| slope \( = 2 \)|
• two frictions in background:
  1. in period 1 output not fully pledgeable (e.g. stealing)
    • implies $p = C/K$ instead $p = 1$
    • otherwise $C$-person could hire $K$-person to harvest capital
  2. no contract on skill (e.g. misreporting)
- ex post cash-in-the-market price ensures efficient allocation, but distorts ex ante incentives
- a form of pecuniary externality
- the sign of distortion depends on relative supply
- symmetry: the relative supply matters, overinvest in scarce one
- the formal dynamic model: capital produces cash, solve for interim prices and investment, generalize the two-sided inefficiencies
Model

- consumption good and capital good: cash $C_t$ and capital $K_t$
  - final date with Poison intensity $\xi$: capital produces $R$ or 0
  - before it arrives, generate positive or negative cash (non-persistent $AK$ technology)
    
    $$dC_t = K_t \sigma dZ_t$$

- if negative, capital needs maintenance
- market populated by long-lived risk neutral firms who can:
  - invest: build new capital for $h$
  - disinvest: dismantle capital for $l (< h)$
  - trade capital for market price (in terms of cash) $p_t$

- zero discount rate, storage technology available
• No outside cash
• Unverifiable idiosyncratic shock: in final date firms learn that they differ in their skills
  • half "hit by skill-shock": can invest in a new technology $u > 1$, but cannot use capital (produce 0)
  • half "are not hit": cannot invest in new technology, but experience productivity hike on capital (produce $R$ per unit)
  • a last round of trade before production or investment into new technology
• $\frac{R}{h} > u$, building capital socially optimal
Motivation

Example

Model

Equilibrium

Externalities

Applications

Alternative Specification

Literature

Conclusion

Timeline

Ex ante

every instant firms build, liquidate and trade capital setting \( d\alpha_t, dK_t^l, K_t^l, C_t^l \)

interim shock \( dC_t \) is realized, price \( p_t \) is set

Ex post

skill shock announced

firms trade for \( p_T \)

firms produce \( (R) \), invest in new opportunity \( (u) \) and consume the proceeds

Note that trade guarantees ex post allocation efficiency
Ex-ante

Every instant firms build, liquidate and trade capital setting $d\alpha_t, dK_t, K_t^t, C_t^t$. Interim shock $dC_t$ is realized, price $p_t$ is set.

Ex-post

Skill shock announced, firms trade for $p_T$, and consume the proceeds.

$C = \frac{1}{2}Kp_T \Rightarrow p_T = c$

- Ex-post agents with skill-shock sell, others buy:

- (as long as $c < R$ which we make sure)

- Note that trade guarantees ex post allocation efficiency
• firms $i$ maximizes

$$
\max_{d\alpha_i^t \geq 0, K_t^i, C_t^i, dK_t^i} E_t \left[ \int_0^\infty d\alpha_t^i \right] = \\
= \max_{d\alpha_t^i, K_t^i, C_t^i, dK_t^i} E_t \left\{ \int_0^\infty \xi e^{-\xi t} \left[ \int_0^t d\alpha_s + \left[ \frac{1}{2} \left( K_t^i + \frac{C_t^i}{p_T} \right) R + \frac{1}{2} \left( K_t^i, p_T + C_t^i \right) u \right] \right] \right\}
$$

• subject to $w_t^i \equiv p_t K_t^i + C_t^i \geq 0$ and

$$
dw_t^i = -d\alpha_t^i - (1_{dK_t^i > 0} h + 1_{dK_t^i < 0} l) dK_t^i + K_t^i \left( dp_t + \sigma dZ_t \right)
$$
Solving for the Equilibrium

- Looking for standard Walrasian equilibrium
- In general only aggregate quantities determined: we can pick the symmetric one
- Value function is separable!

\[ J(C, K, K_i, C^i_t) = K^i_t v(c) + C^i_t q(c). \]

- state variable: cash to asset ratio, \( c_t \equiv \frac{C_t}{K_t} \)
• pricing by indifference:

\[ p = p(c) \equiv \frac{v(c)}{q(c)} \]

• build capital when \( p = h \), liquidate capital when \( p = l \)
  • keeps \( c \) between reflective barriers \( c_h^*, c_l^* \)
• value of cash, \( q \) always larger than 1, consume only at maturity
• pricing by indifference:

\[ p = p(c) \equiv \frac{v(c)}{q(c)} \]

• build capital when \( p = h \), liquidate capital when \( p = l \)
  • keeps \( c \) between reflective barriers \( c_h^*, c_l^* \)
• value of cash, \( q \) always larger than 1, consume only at maturity
• HJB gives separate ODEs for \( v \) and \( q \): have closed form general solutions
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**Price of capital**

![Graph of price of capital](image)

- **p(c)**: aggregate cash-to-capital ratio, c = C/K
- **Value of capital**: h

**Value of cash**

![Graph of value of cash](image)

- **q(c)**: aggregate cash-to-asset ratio, q = C/A
- **Value of cash**: q

**Value of capital**

![Graph of value of capital](image)

- **v(c)**: aggregate cash-to-capital ratio, c = C/K
- **Value of capital**: v
Constrained Efficient Benchmarks

- Second Best benchmarks:
  1. Social Planner can pick investment/disinvestment, but cannot influence ex-post allocation
  2. either idiosyncratic shocks are verifiable or $R, u$ are pledgeable

- recall: ex post distribution is efficient, inefficiency is driven by ex ante investment decision

- both benchmarks lead to same ex-ante value and same thresholds: $c_i^P, c_h^P$
aggregate cash-to-asset ratio, $c = \frac{C}{A}$

Value of cash

$\pi(c), \pi_{cm}(c)$

aggregate cash-to-capital ratio, $c = \frac{C}{K}$

Value of capital

$v(c), v_{cm}(c)$
• distorted incentives in market solution
  • social planner:
    • cares only about the trade-off: capital is productive \( \frac{R}{h} > u \)
    • but risky: if aggregate cash is low, might be liquidated inefficiently
    • values cash as a buffer against inefficient liquidation
    • but does not care about \( p_T \)!
  • individual agents:
    • care also about inefficient liquidation
    • but also care about available rent through last minute trading \( (p_T) \)
    • e.g. \( C_t \) very low (high), price of capital expected to be very low (high), they overinvest in cash (capital).
• missing market to trade the state of skill-shock ⇒ distorted ex-post price ⇒ changed incentives to hold cash/capital ⇒ distorted ex-ante price ⇒ distorted investment thresholds

• Critical element: price distortion changes sign with business cycle!
• as $p_T = c$ and fluctuates in $[c^*_l, c^*_h]$ for two-sided inefficiency we need (app.):

$$\min(p_T) = c^*_l < \frac{R}{u} < c^*_h = \max(p_T)$$

• first inequality always holds, second one depends
• vaguely:
  • when capital are very productive, large $R/h - u$: underinvestment in booms as well
  • when capital are not that productive, over investment in booms
• we have propositions that formally show the existence of two-sided inefficiency
Application I: Inefficient Construction Waves

- consider a real-estate developer who faces different investment opportunities each time (i.e., Donald Trump)
- has to decide how to store his capital he might want to invest at a future opportunity
- our model: relative liquidity of capital and consumption good varies over the cycle
- bad times: real estate can be sold only with a discount, not a good store of value, developer prefers to hoard cash, push price even further, disinvestment
- good times: real estate can be sold for high price, liquid store of value, push price higher, developer builds more.
"Reverse fire-sale" pattern in Japan:

It took most Japanese banks years to whittle down the tens of billions of dollars in unrecoverable loans left on their books after the collapse of a real estate bubble[...]. But analysts criticize most banks for failing to find new, more profitable – and less risky – ways of doing business. Instead, analysts say many have gone back to lending heavily to real estate development companies and investment funds, as the rebounding economy has touched off a construction boom in Tokyo. "If the economy stalled, Japanese banks would have a bad loan problem all over again," said Naoko Nemoto, an analyst for Standard & Poor's in Tokyo. (The New York Times, January 17, 2006)
Application II: Real and Financial Industry Booms and Busts

- Hoberg-Phillips (JF, 2010)
- high valuation, investment, financing predicts low profitability
- Not necessarily along famous stories:
  - 1970s: Motion Picture Theaters, Wholesale Apparel
  - 1980s: Electrical Work, Paper Products
  - 2000s: Coal Mining, Management and Consulting Services
• only in competitive industries
  • their story: signal extraction problem from return shocks
  • our story: no contracts on future investment opportunities
    ⇒ pecuniary externality
      • would not occur in a non-competitive setting where agents take into account their price effect
      • (we show this formally for the two-period version)
Application III: Financial Development and Volatility

- (financially) less developed countries experience less growth and more volatile growth
- consistent if we measure
  - growth by expected final production (or consumption) compared to current size of economy:
    \[ E(K_t R_t + C_t u) \]
    \[ \frac{K_0}{K_t} \]
  - volatility of growth by expected total adjustment of capital:
    \[ E \left( \int \frac{|dK_t|}{K_t} \right) \]
  - compare incomplete market setting (less developed) with complete market setting (more developed)
  - new element: excess volatility partly comes from too much investment in productive assets in booms
One-sided interventions

- Suppose government realizes only the inefficiency in recessions
- when \( p \) gets close to \( l \) intervene:
  - One-sided intervention: tax cash, subsidize capital, keep a balanced budget, stop it when the price is sufficiently high again
  - If two-sided inefficiency: one-sided intervention makes over investment in booms worse
  - Ex-ante value takes full distribution into account! it is a conditional expectation given the current state
  - Adverse effect in booms can be so bad that ex-ante welfare goes down everywhere
  - Even if intervention effective in recession, everyone is worse off even in the recession
• But: If underinvestment in booms as well, one-sided intervention makes sense!
• depends on relative size of $R/h - u$ and $\gamma \equiv \frac{\sqrt{2\xi}}{\sigma}$, vaguely:
  • when capital are very productive, large $R/h - u$ : underinvestment in booms as well
  • when capital are not that productive, over investment in booms
Alternative specification

- For general mechanism three main ingredients:
  1. Two assets of which relative supply is affected by a stochastic process.
  2. A group of agents who can transform each asset to the other one by a linear technology, but with some loss in the process.
  3. An idiosyncratic shock which changes some agents’ relative valuation of the assets compared to other agents.

- essentially symmetric structure
- timing is not important
• We can get rid of two-stage dynamic structure: results remain the same, more natural, less tractable, less transparent

• in each instant:
  • $\phi$ fraction of capital mature, agent who holds the capital eats the resulting cash
  • $\xi$ friction realizes that cannot harvest, but learns about opportunity, sells assets and invest outside for $u$
- can invest and disinvest only occasionally: when another aggregate Poisson-event hits, they can do to the extent they want: still thresholds
  - if event hits AND $c < c^*_l$: disinvest till $c$ jumps to $c^*_l$ and price jumps to $l$
  - if event hits AND $c > c^*_h$: invest till $c$ drops to $c^*_h$ and price drops to $h$
- how would social value change, if the planner changes the thresholds a bit?
Alternative specification

Panel A: marginal value of cash

Panel B: marginal value of capital

Panel C: price of capital

Panel D: ratio of value functions

\[ \frac{(j_s - j)}{j} \text{ with } c_l < c^*_l \]
\[ \frac{(j_s - j)}{j} \text{ with } c_h > c^*_h \]
\[ \frac{(j_s - j)}{j} \text{ with } c_h > c^*_h, \ c_l < c^*_l \]
• instead of ex-ante price and ex-post price, just price
• serves both (conflicting) roles
  1. determines terms of transfer for exit (if new investment opportunity)
  2. drives investment decision
• just as ex-post price before, first function changes incentives how to store wealth
  • increases price in booms, decreases price in recessions
  • distorts second function
Literature

  - Investment with inaction region: Abel and Eberly (1994)
Conclusion

- Constraint on aggregate capital: investment waves, can be constrained efficient
- Unverifiable idiosyncratic shock for relative value of productive assets and cash: inefficiency
  - ex post cash-in-the-market price ensures efficient allocation, but distorts ex ante incentives
  - a form of pecuniary externality
  - the sign of distortion depends on relative supply
- Dynamic model:
  - relative supply is given by the state of the cycle
  - policy experiments with agents appreciating the eternal fluctuation
- Cool framework: fully dynamic model with analytical tractability, we will use it for other cool stuff