Dynamic Inefficiency in Decentralized Capital Markets

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Introduction

Assets often trade in frictional decentralized markets

- Financial assets in OTC markets
- Physical capital

Questions:

- Is the allocation of capital inefficient?
- What are the policy implications?

What we do

- We analyze a model environment in which firms match bilaterally with dealers in order to buy/sell capital
- Terms of trade determined by bargaining
- Two motives for trade
    - Depreciation
    - Productivity shocks

What we find

- Equilibrium is constrained inefficient
  - Firms who anticipate buying capital in the future overinvest in capital today
  - Firms who anticipate selling capital in the future underinvest in capital today
  - Key to this result is that firm's current capital level affects future bargaining position

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- If the only motive for trade is depreciation, firms always overinvest
- With heterogeneous productivity, low-productivity firms overinvest, and high-productivity firms underinvest
- A regressive tax on capital can implement the efficient allocation

Relationship to Literature

- Allocations in decentralized asset markets
  - Duffie et al. (2005, 2007), Hugonnier, Lester and Weill (2015), ...
  - Lagos and Rocheteau (2009), Lagos, Rocheteau and Weill (2011), Lester, Rocheteau and Weill (2015),...
  - This paper: focus on normative/policy implications

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  - This paper: focus on normative/policy implications
- Overemployment of inputs to strategically improve bargaining position
  - Stole and Zwiebel (1996), Smith (1999), Cahuc, Marque and Wasmer (2008), Acemoglu and Hawkins (2014), Kurmann (2014), Brugemann, Gautier and Menzio (2015),...
  - Analogous inefficiency, in a dynamic environment

Deterministic model

- Discrete time, infinite horizon
- Two types of agents: *firms* and *dealers*, both with linear utility from consumption
- Firms: have a technology $y = f(k)$ for producing the consumption good using capital; $f' > 0$, $f'' < 0$
- Dealers: have a linear technology for converting capital into consumption and vice versa
- Capital accumulates according to $k' = (1 - \delta) k + x$

Matching and bargaining

- Every period, firms and dealers match bilaterally: matching probability $\lambda \in (0, 1]$
- Dealer observes firm's current capital level
- Nash bargaining determines the terms of trade: amount of capital bought/sold by the firm, and transfer of consumption

Planner's problem

$$\begin{aligned} \Upsilon(k) &= f(k) + \lambda \max_{k'} \left[- \left(k' - (1-\delta)k \right) + \beta \Upsilon(k') \right] \\ &\quad + (1-\lambda)\beta \Upsilon\left((1-\delta)k \right) \end{aligned}$$

Planner's problem

$$\begin{aligned} Y(k) &= f(k) + \lambda \max_{k'} \left[-\left(k' - (1-\delta)k\right) + \beta Y(k') \right] \\ &\quad + (1-\lambda)\beta Y\left((1-\delta)k\right) \end{aligned}$$

Solution for Y:

$$Y(k) = Y(0) + \sum_{t=0}^{\infty} \left(\beta(1-\lambda)\right)^t \left[f\left((1-\delta)^t k\right) + \lambda (1-\delta)^{t+1} k \right]$$

Planner's problem

The optimal $k' = k^P$ solves

$$1 = \beta \sum_{t=0}^{\infty} (\beta(1-\lambda)(1-\delta))^t \left[f'\left((1-\delta)^t k^P \right) + \lambda (1-\delta) \right]$$

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$$
\begin{aligned}
1 &= \beta \sum_{t=0}^{\infty} (\beta(1-\lambda)(1-\delta))^t \left[f'\left((1-\delta)^t k^P \right) + \lambda (1-\delta) \right] \\
&\geq \beta \left[f'\left(k^P\right) + 1 - \delta \right]
\end{aligned}
$$

Decentralized equilibrium

$$v\left(k\right)=f\left(k\right)+\lambda\max_{k'}\left[-\omega\left(k,k'\right)+\beta v\left(k'\right)\right]+(1-\lambda)\beta v((1-\delta)k)$$

The transfer ω is determined by Nash bargaining:

$$\omega\left(k,k'\right)=\phi\left(\beta v\left(k'\right)-\beta v\left(\left(1-\delta\right)k\right)\right)+\left(1-\phi\right)\left(k'-\left(1-\delta\right)k\right)$$

where $\phi =$ dealer's bargaining weight

Decentralized equilibrium

$$\begin{aligned} v(k) &= f(k) + \lambda(1-\phi)\max_{k'}\left[-\left(k' - (1-\delta)k\right) + \beta v\left(k'\right)\right] \\ &\quad + (1-\lambda(1-\phi))\,\beta v((1-\delta)k) \end{aligned}$$

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Solution for v:

$$v(k) = v(0) + \sum_{t=0}^{\infty}\left(\beta\left(1-\hat{\lambda}\right)\right)^{t}\left[f\left((1-\delta)^{t}k\right) + \hat{\lambda}(1-\delta)^{t+1}k\right]$$

where $\hat{\lambda} = \lambda(1-\phi)$

Decentralized equilibrium

The equilibrium $k' = k^D$ satisfies

$$1 = \beta \sum_{t=0}^{\infty} \left(\beta(1 - \lambda\,(1 - \phi))\,(1 - \delta)\right)^t \left[f'\left((1 - \delta)^t k^D\right) + \lambda\,(1 - \phi)\,(1 - \delta)\right]$$

Overinvestment result

Proposition

$k^D \geq k^P$, *strict as long as* $\phi > 0$ *and* $\delta \in (0,1)$.

Intuition:

- Firm's individual problem is identical to planner's problem, except λ replaced by $\lambda(1-\phi)$
- Firm's k increases its outside option in future negotiations

Overinvestment result

Limiting cases:

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1. $\delta = 0 \implies k^D = k^P$
   - Firm purchases capital only once

Overinvestment result

Limiting cases:

1. $\delta = 0 \implies k^D = k^P$
   - Firm purchases capital only once
2. $\delta = 1 \implies k^D = k^P$
   - Capital no longer a state variable

Stochastic model

- Assume $y = zf(k)$, z is an idiosyncratic shock
- Law of motion for z:
    - With probability γ, $z' = z$
    - With probability $1 - \gamma$, draw a new z' from an invariant distribution π
    - Define $\bar{z} = \sum_j \pi_j z_j =$ unconditional mean of π

Optimal capital choice

Planner's problem:

$$\begin{aligned} \Upsilon(k,z) &= zf(k) + \lambda \max_{k'} \left[-\left(k' - (1-\delta)k\right) + \beta \mathbb{E}_{z'|z} \Upsilon(k',z') \right] \\ &\quad + (1-\lambda)\beta \mathbb{E}_{z'|z} \Upsilon\left((1-\delta)k, z'\right) \end{aligned}$$

Decentralized equilibrium:

$$\begin{aligned} v(k,z) &= zf(k) + \lambda(1-\phi) \max_{k'} \left[-\left(k' - (1-\delta)k\right) + \beta \mathbb{E}_{z'|z} v\left(k',z'\right) \right] \\ &\quad + \left(1 - \lambda(1-\phi)\right) \beta \mathbb{E}_{z'|z} v((1-\delta)k, z') \end{aligned}$$

Inefficiency with heterogeneous productivity

Suppose $\delta = 0$.

- $k^P(z)$ solves

$$\frac{1}{f'(k)} = \frac{\beta}{1-\beta}\left(\tilde{\gamma}^P z + \left(1 - \tilde{\gamma}^P\right)\bar{z}\right), \ \tilde{\gamma}^P = \frac{\gamma - \gamma\beta(1-\lambda)}{1 - \gamma\beta(1-\lambda)}$$

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Inefficiency with heterogeneous productivity

Proposition

Suppose $\delta = 0$. *Then* $k^D(z) > k^P(z)$ *for* $z < \bar{z}$, *and* $k^D(z) < k^P(z)$ *for* $z > \bar{z}$.

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Intuition:

- Firms overinvest when they anticipate buying in the future, and underinvest when they anticipate selling
- For mean-reverting z, low-productivity firms overinvest, high-productivity firms underinvest

Inefficiency with heterogeneous productivity

Proposition

Suppose $\delta > 0$ *and* $f(k) = k^{\alpha}$.

1. *If* $\gamma (1-\delta)^{\alpha-1} > 1$, *then* $k^D(z) > k^P(z)$ *for all* z.
2. *If* $\gamma (1-\delta)^{\alpha-1} \leq 1$, *then* $k^D(z) > k^P(z)$ *for* $z < \hat{z}$, *and* $k^D(z) < k^P(z)$ *for* $z > \hat{z}$, *where* $\hat{z} > \bar{z}$.

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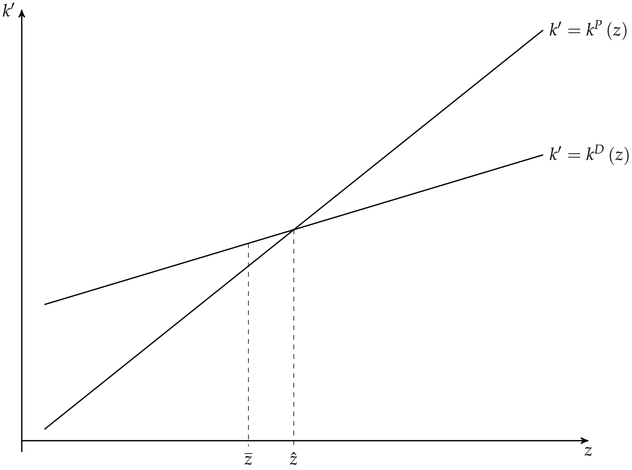
Intuition:

- All else equal, higher depreciation leads to more overinvestment
- Firms underinvest if there is a sufficiently large probability of reversion to low productivity

Inefficiency with heterogeneous productivity



Inefficiency with heterogeneous productivity

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Inefficiency with heterogeneous productivity

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- For any $\delta \in [0, 1)$,
  1. $\gamma = 1 \implies k^D(z) \geq k^P(z)$ for all z, with equality if and only if $\delta = 0$
     - Productivity expected to remain at current level forever
     - Depreciation is the only motive for trade

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  2. $\gamma = 0 \implies k^D(z) \geq k^P(z)$ for all z, with equality if and only if $\delta = 0$
     - Current productivity unimportant for future capital choice
- At $\delta = 1$, we still have $k^D(z) = k^P(z)$ always

Taxation

- Suppose a firm exiting a decentralized meeting with k' is taxed $\tau(k')$
- What tax function τ restores efficiency?
- Pick $\tau(k')$ such that

$$1 + \tau'\left(k^{P}(z)\right) = \beta \mathbb{E}_{z'|z} v\left(k^{P}(z), z'\right)$$

Taxation

Proposition

1. *Suppose* $\delta = 0$. *Then there exists a* τ *implementing the efficient allocation, satisfying* $\tau''(k) < 0$. *Furthermore,* $\tau'(k) > 0$ *for* $k < k^P(\bar{z})$, $\tau'(k) < 0$ *for* $k > k^P(\bar{z})$.
   - *For the case* $\delta = 0$, *this is equivalent to a regressive wealth tax.*
2. *Suppose* $\delta \geq 0$ *and* $f(k) = k^\alpha$. *Then there exists a* τ *implementing the efficient allocation, satisfying* $\tau''(k) < 0$. *Furthermore,* $\tau'(k) > 0$ *for* $k < k^P(\hat{z})$, $\tau'(k) < 0$ *for* $k > k^P(\hat{z})$.

Conclusion

- Firms make inefficient investment choices because their capital holdings affect their future bargaining position
- Low-productivity firms tend to overinvest, high-productivity firms tend to underinvest
- A regressive tax on capital can restore the efficient allocation
- Extension: with free entry of dealers, there is no bargaining power that generates the efficient allocation