Amplification and Spillover with Financial Arbitrage, Production and Collateral Constraints

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Highlight

- general equilibrium of collateral constrained arbitrage in a production economy
- agenda:
  - price difference between identical assets
  - collateral constraints
  - financial markets and production sector
  - spillover and amplification

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  - Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Bernanke, Gertler and Gilchrist (1999)
- tractable equilibrium model
  - explicit theory for production and arbitrage with financial friction
  - closed-from solutions in special cases
- welfare analysis
  - spillover and amplification
  - possible relevance for policy debates
    - systemic risk
    - margin requirement regulation

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Motivation I – Lessons from Financial Crisis

- 1998 financial crisis
  - Arbitrage
    - ★ hedge funds bet on convergence of prices of similar-payoff assets
    - ★ during crisis, prices diverged.
    - ★ hedge funds experienced heavy losses + distress
    - ★ force to liquidate profitable positions
- 2008 financial crisis
  - shocks from the housing sector spill over into financial sectors and reinforce with each other
- asset prices and liquidity:
  - prices pushed away from fundamentals
  - liquidity dried up
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Motivation II

- empirical evidence about persistent price differences
  - "Siamese-twin" stocks:
    - ★ Rosenthal and Young (1990) and Dabora and Froot (1999)
  - Before 1998, the British government bonds vs German bonds
- market segmentation
  - Before Nov 2014, A shares in mainland China and H shares in Hongkong
  - Post-Brexit without financial "passport"
- links between financial friction and macroeconomy
  - Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Bernanke, Gertler and Gilchrist (1999)

Main Conclusions

- with perfect foresight of market demand
  - self-recovery
- with inaccurate estimation of future market demand
  - looser collateral constraints trigger recession
    - ★ spillover and amplification
  - tighter collateral constraints stabilize the economy

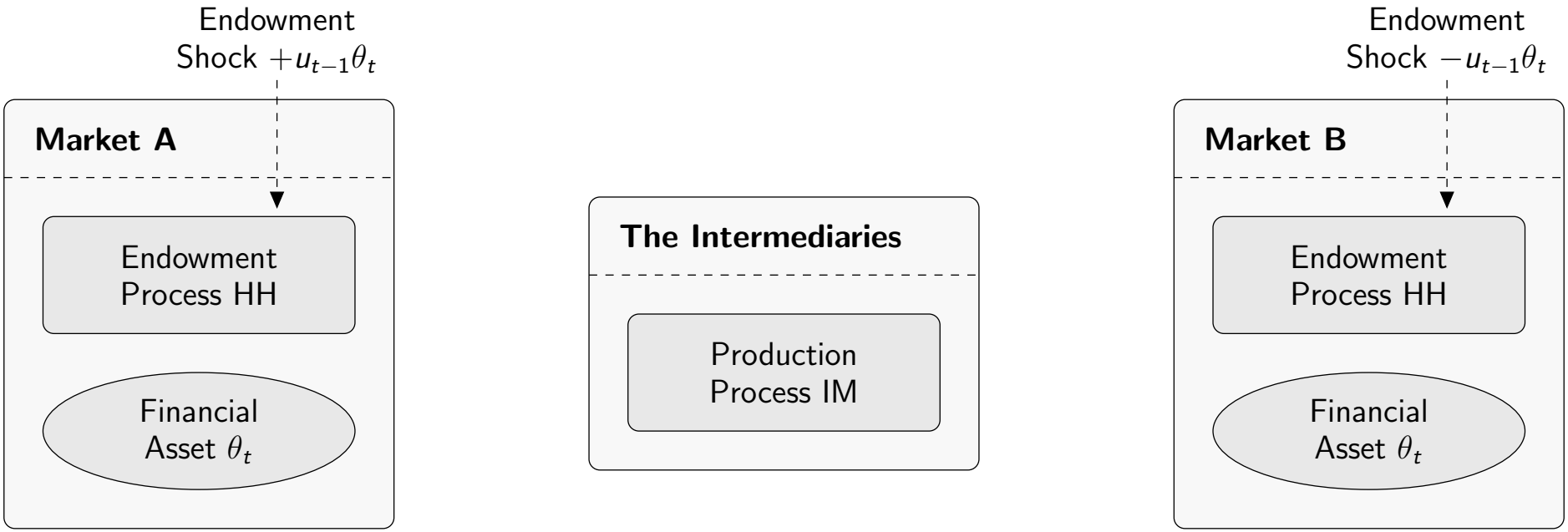
Related Literature

- Vayanos and Gromb (2002, 2015)
  - No production sector
  - The financial constraints must cover the maximum loss of the arbitrageurs.
- Brunnermeier and Sannikov (2014)
  - no financial arbitrage

Baseline Model

Figure: The structure of the economic system.

Baseline Model



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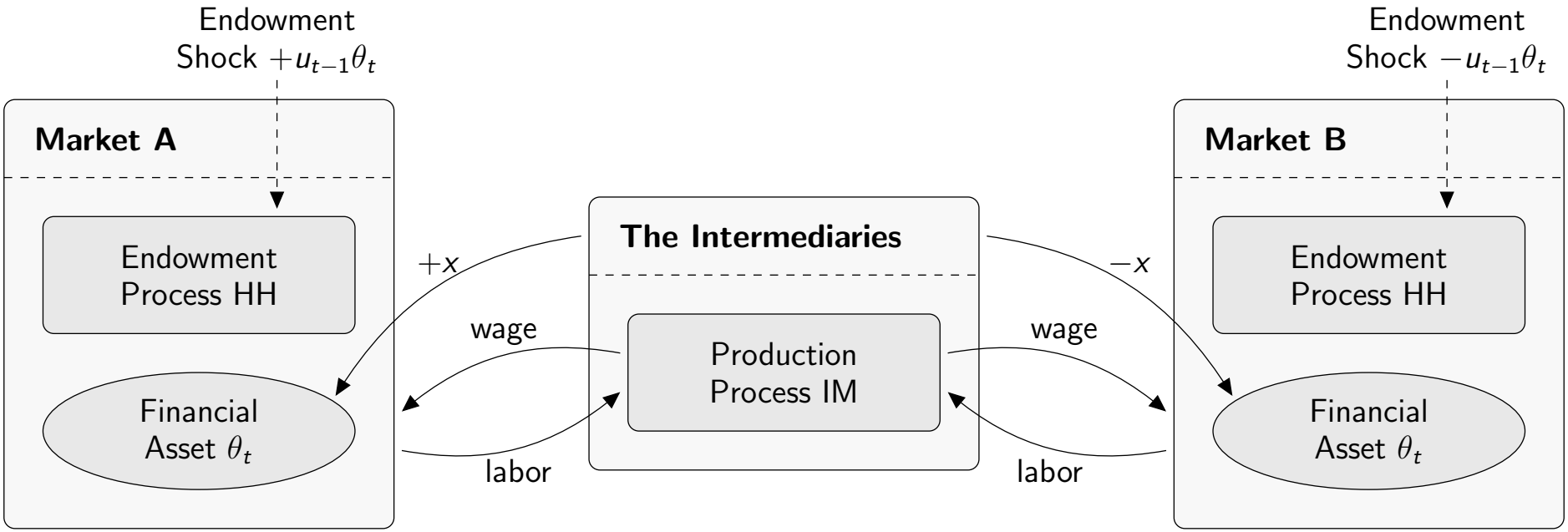

Figure: The structure of the economic system.

Agents

- a continuum of competitive IM and HH
- only one perishable consumption goods
  - IM can convert consumption and capital
- IM are both arbitrageurs and entrepreneurs
  - IM invest capital and HH offer labor.

$$y_t = F(K_{t-1}) = aK_{t-1}^{\alpha} L_t^{\gamma}$$

  - separate collateral posting with capital investment

Exogeneous Shocks

- HH's fixed-size production / natural endowment

$$y_{i,t} = bK_H + u_{i,t-1}\theta_t, \quad i \in \{\mathrm{A}, \mathrm{B}\}, \quad t \in \{1, 2, \dots\}.$$

  - θ_t follows a symmetric distribution around zero on $\left[-\bar{\theta}, \bar{\theta}\right]$.
  - the shock intensities/market demand $u_{A,t} = -u_{B,t} =: u_t$.

- opposite shocks, opposite hedging demand

Financial Assets

- identical financial assets in each market
  - dividend θ_t mimicks the shock
  - long-lived, in zero net supply
  - IM and HH's position $x_{i,t}^{\text{IM}}$ and $y_{i,t}^{\text{HH}}$.
- prices differ across markets
  - opposite hedging demand A : $-u_{\text{A,t}} = -u_t$; B : $-u_{\text{B,t}} = u_t$.
- IM exploit arbitrage profit

Collateral Constraints

- IM take identical but opposite positions $x_{A,t} = -x_{B,t} = x_t$.
  - measure of market liquidity
- collateral constraints
  - separately post capital input as collateral
  - cover HH's maximum loss if IM default or walk away from their positions
  - total collateral limit: IM's capital rent $\alpha F(K_t)$.

IM's Optimization Problems

$$\max_{c_s^{\mathrm{IM}}, x_{i,s}, K_s} \mathbb{E}\left[\sum_{s=t}^{\infty} \rho^s \log\left(c_s^{\mathrm{IM}}\right)\right], \quad i \in \{\mathrm{A}, \mathrm{B}\}.$$

subject to

$$c_t^{\mathrm{IM}} = \underbrace{\sum_{i\in\{\mathrm{A},\mathrm{B}\}} x_{i,t-1}^{\mathrm{IM}} p_{i,t}}_{\substack{\text{value of previous}\\ \text{period's investment}\\ \text{in financial asset } i}} - \underbrace{\sum_{i\in\{\mathrm{A},\mathrm{B}\}} x_{i,t}^{\mathrm{IM}} p_{i,t}}_{\substack{\text{current cost}\\ \text{of taking}\\ \text{new positions}\\ \text{or immediate}\\ \text{arbitrage profit}}} + \underbrace{a(1-\gamma)K_{t-1}^{\alpha} L^{\gamma} - K_t}_{\substack{\text{entrepreneur income: net production output}\\ \text{minus wage and investment}}}$$

$$\sum_{i\in\{\mathrm{A},\mathrm{B}\}} \min\Big\{ \min_{p_{i,t+1}, \theta_{t+1}} \left\{ x_{i,t}^{\mathrm{IM}} (p_{i,t+1} + \theta_{t+1}) \right\}, 0 \Big\} + \alpha F(K_t) \geq 0.$$

HH's Optimization Problems

$$\max_{c_{i,s}^{HH}, y_{i,s}^{HH}} \mathbb{E}\left[\sum_{s=t}^{\infty} \beta^s \log\left(c_{i,s}^{HH}\right)\right]$$

subject to

$$c_{i,t}^{HH} = \underbrace{\left(y_{i,t-1}^{HH}(p_{i,t}+\theta_t) - y_{i,t}^{HH} p_{i,t}\right)}_{\text{income from trading financial asset}} + \underbrace{\frac{1}{2} a\gamma K_{t-1}^{\alpha} L^{\gamma}}_{\text{labor Income}} + \underbrace{\left(bK_H + u_{i,t-1}\theta_t\right)}_{\text{endowment}}$$

- Ideally, $y_{i,t-1}^{HH} = -u_{i,t-1}$ so that households are fully protected from the endowment shock θ_t.

Competitive Equilibrium

For any initial capital endowment, an equilibrium is described by the price process $p_{i,t}$, IM's capital investment K_t, financial asset positions $y_{i,t}^{\text{HH}}$ and $x_{i,t}^{\text{IM}}$, and consumption choices c_t^{IM} and $c_{i,t}^{\text{HH}}$ for $i \in \{\text{A}, \text{B}\}$ such that

- all agents solve their optimization problems given prices;
- markets clear for financial assets, that is $y_{i,t}^{\text{HH}} + x_{i,t}^{\text{IM}} = 0$.

Riskless Arbitrage

When shock intensity is known to agents, there exist one steady state

- if $\rho \geq \frac{(2\max\{|u_t|\}\bar{\theta})^{\frac{1-\alpha}{\alpha}}}{a^{\alpha}\alpha}$, then $\alpha\rho F'(K^*) = 1$, $C^* = (1-\alpha\rho)F(K^*)$, $x_t = u_t$, price difference $|\psi^*|$ is 0.
- otherwise if u_t is constant, then K_t converges over time to a unique K*, with price discrepancy $|\psi^*| > 0$ and market liquidity $x^* = \frac{\alpha F(K^*)}{2\bar{\theta}+|\zeta^*|} < u$.

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Steady State with Binding Collateral Constraints

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- net zero financial income
- without arbitrage, $\rho F'(K_n^*) = \frac{1}{\alpha}$
- $\rho F'(K_n^*) = \frac{1}{\alpha'}$, capital elasticity $\alpha' = \alpha + \alpha\frac{1-\rho}{\rho}\frac{|\psi^*|}{2\bar{\theta}+|\zeta^*|} > \alpha$
- $K^* > K_n^*$
- nominal zero-interest debt, leveraged production
- reduced marginal cost of physical investment

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Equilibrium Existence and Uniqueness

Proposition

When the shock intensity u_t is constant, a unique competitive equilibrium exists in which the price difference ψ_t, intermediaries' capital investment K_t and the positions of the financial assets x_t^i are deterministic.

Shock Reactions–Self-recovery

In case of a sudden loss in capital input or financial income,

- immediate reaction

  price difference: $|\psi_{t+1}| > |\psi^*|$, market liquidity: $|x_{t+1}| < x^*$, $K_{t+1} < K^*$.

  - marginal return of capital
  - arbitrage profitability

- long term

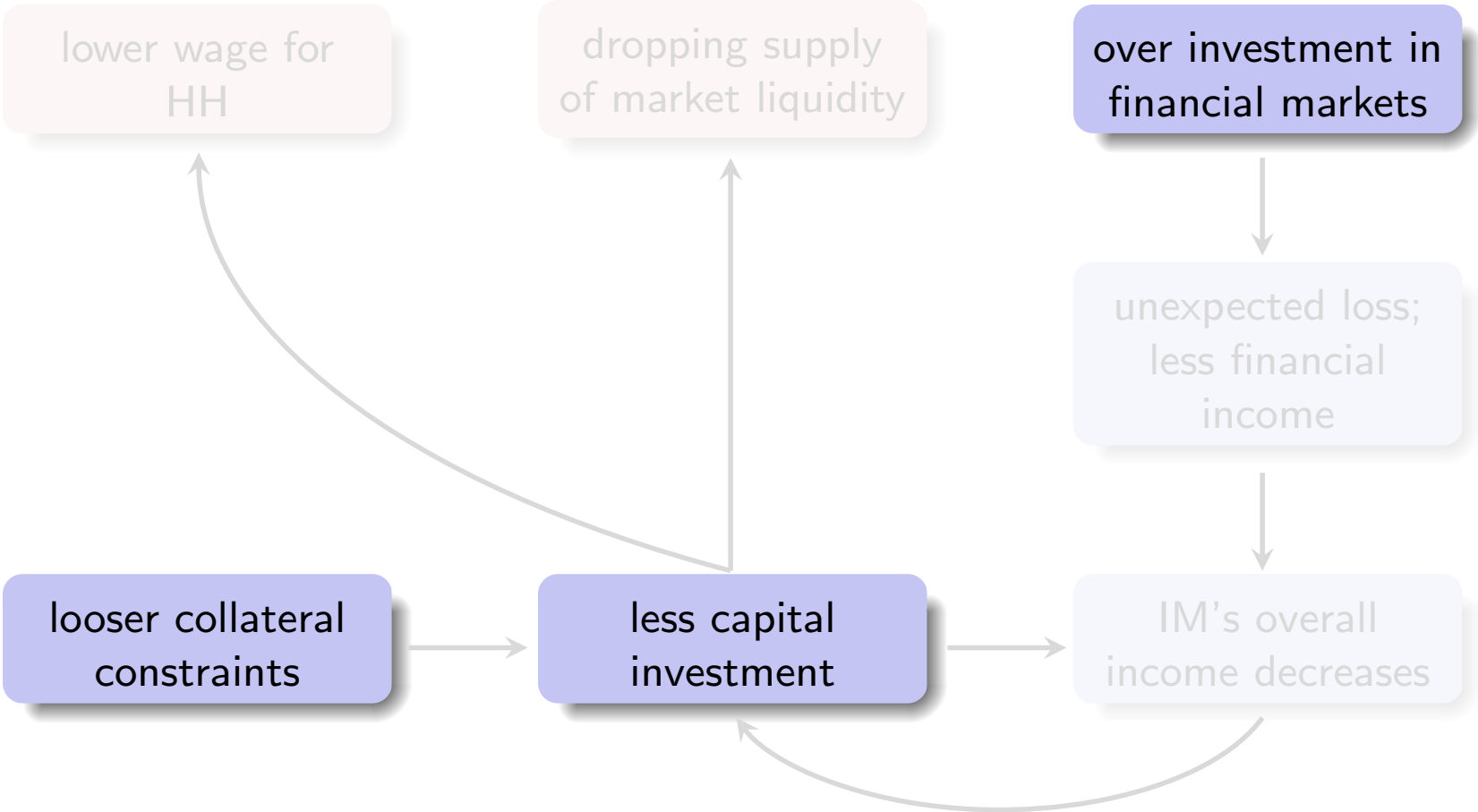
  price difference: $|\psi_t| > |\psi_{t+1}| > \cdots > |\psi^*|$,
  market liquidity: $|x_t| < |x_{t+1}| < \cdots < |x^*|$,
  $K_t < K_{t+1} < \cdots < K^*$.

Risky Arbitrage – Looser Collateral Constraints

With uncertainty, agents might underestimate or overestimate the market demand.

- underestimate case
  - looser collateral constraints
  - overinvestment in financial markets
  - spillover and amplification
  - trigger recession & systemic risk

Spillover and Amplification Effects



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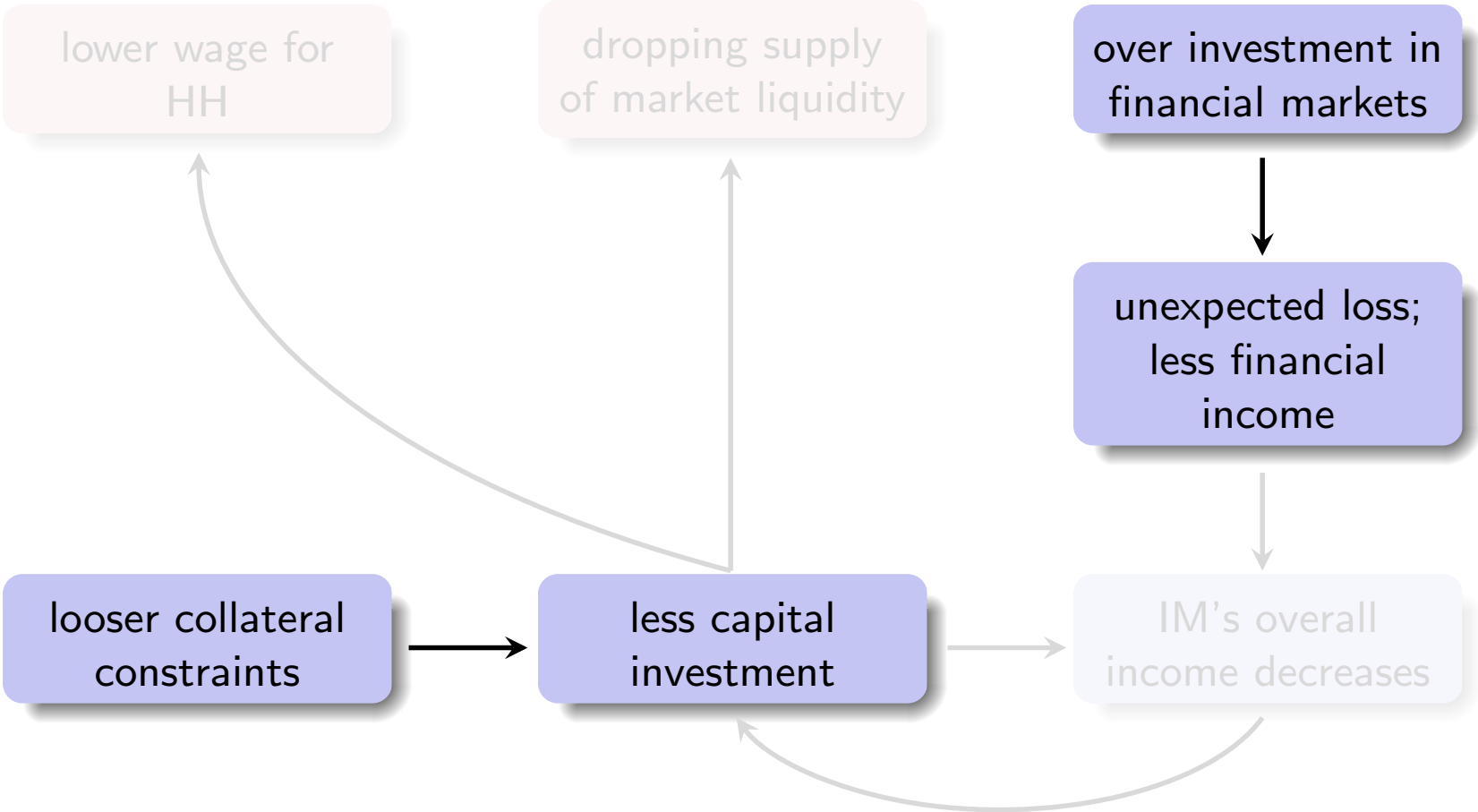

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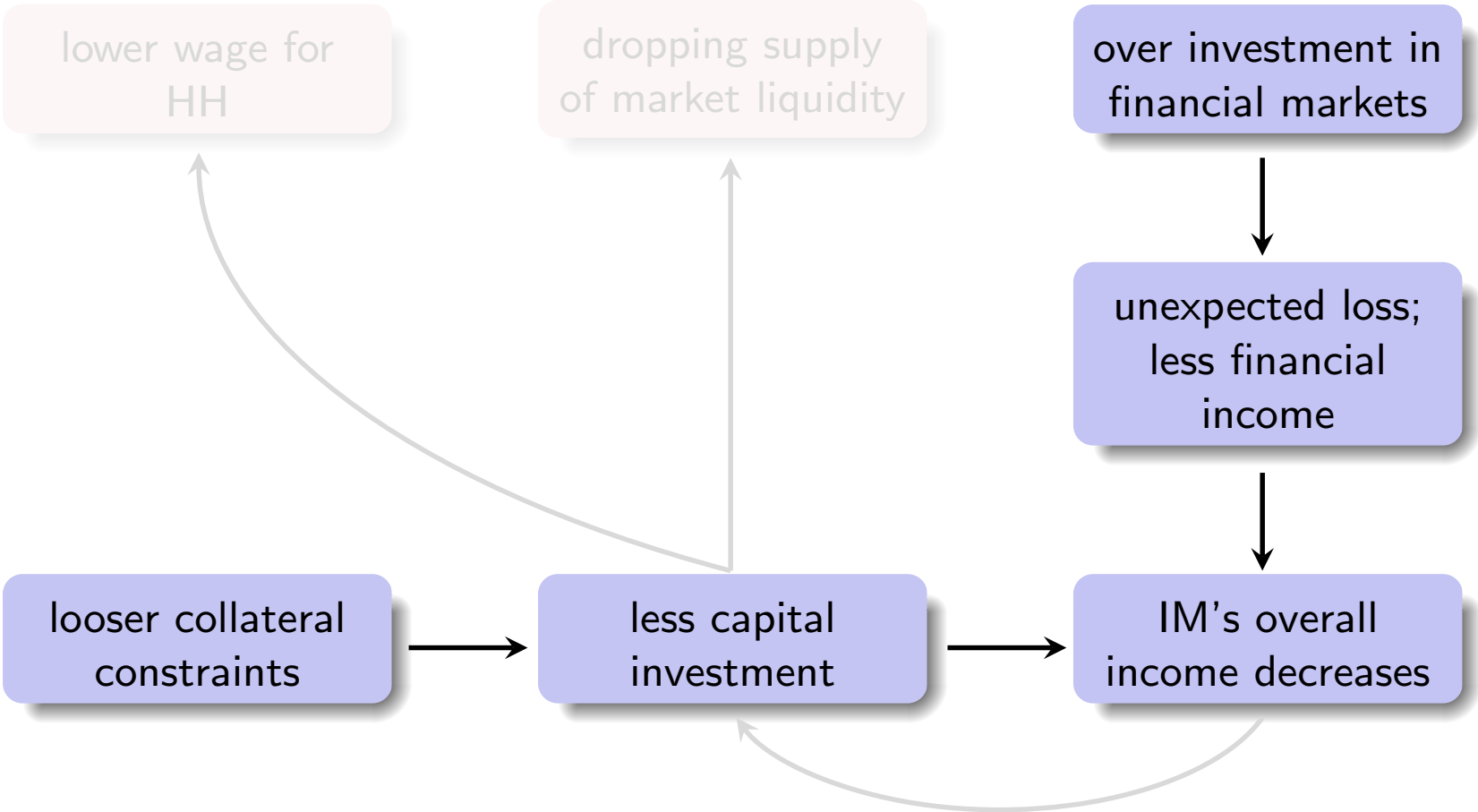

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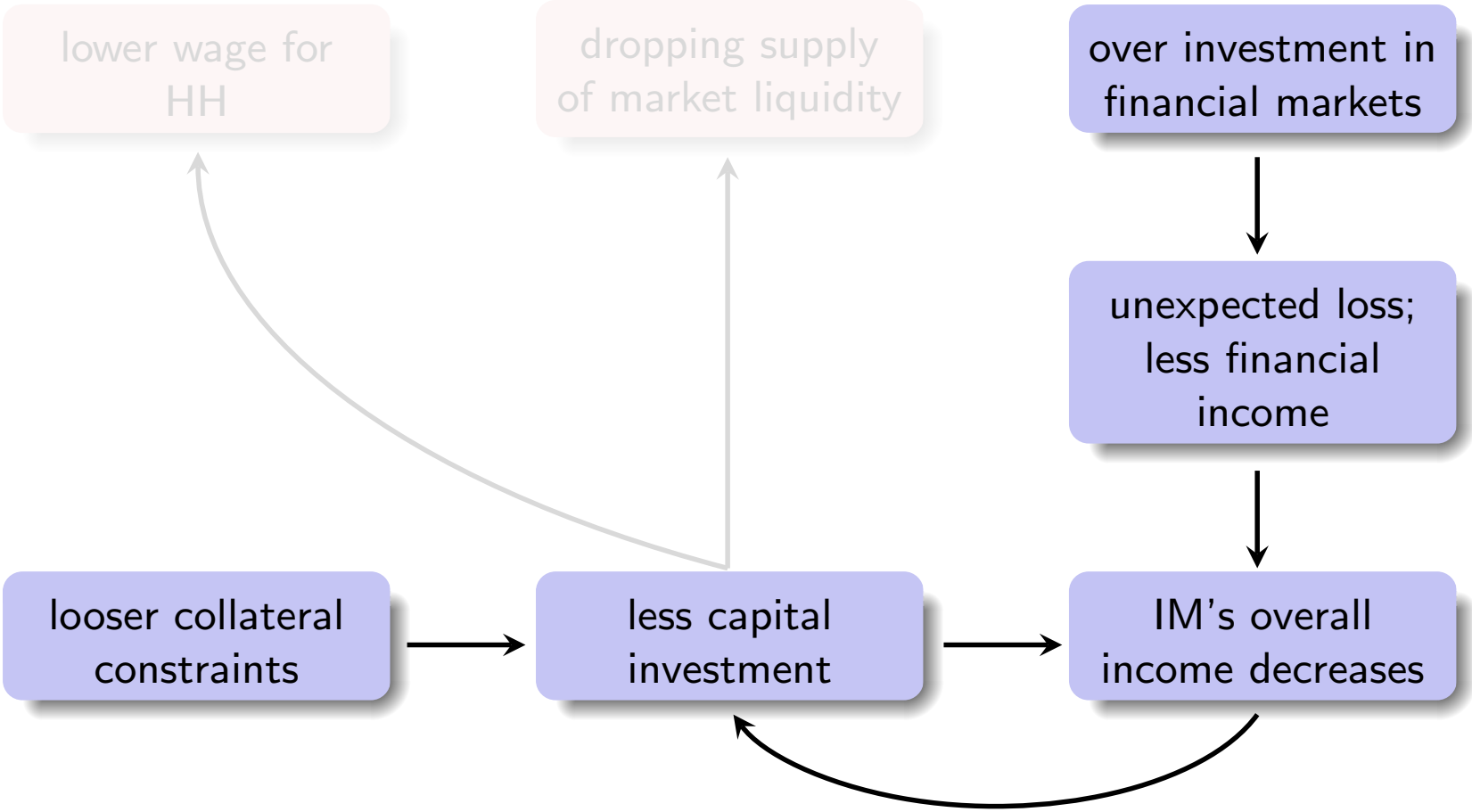

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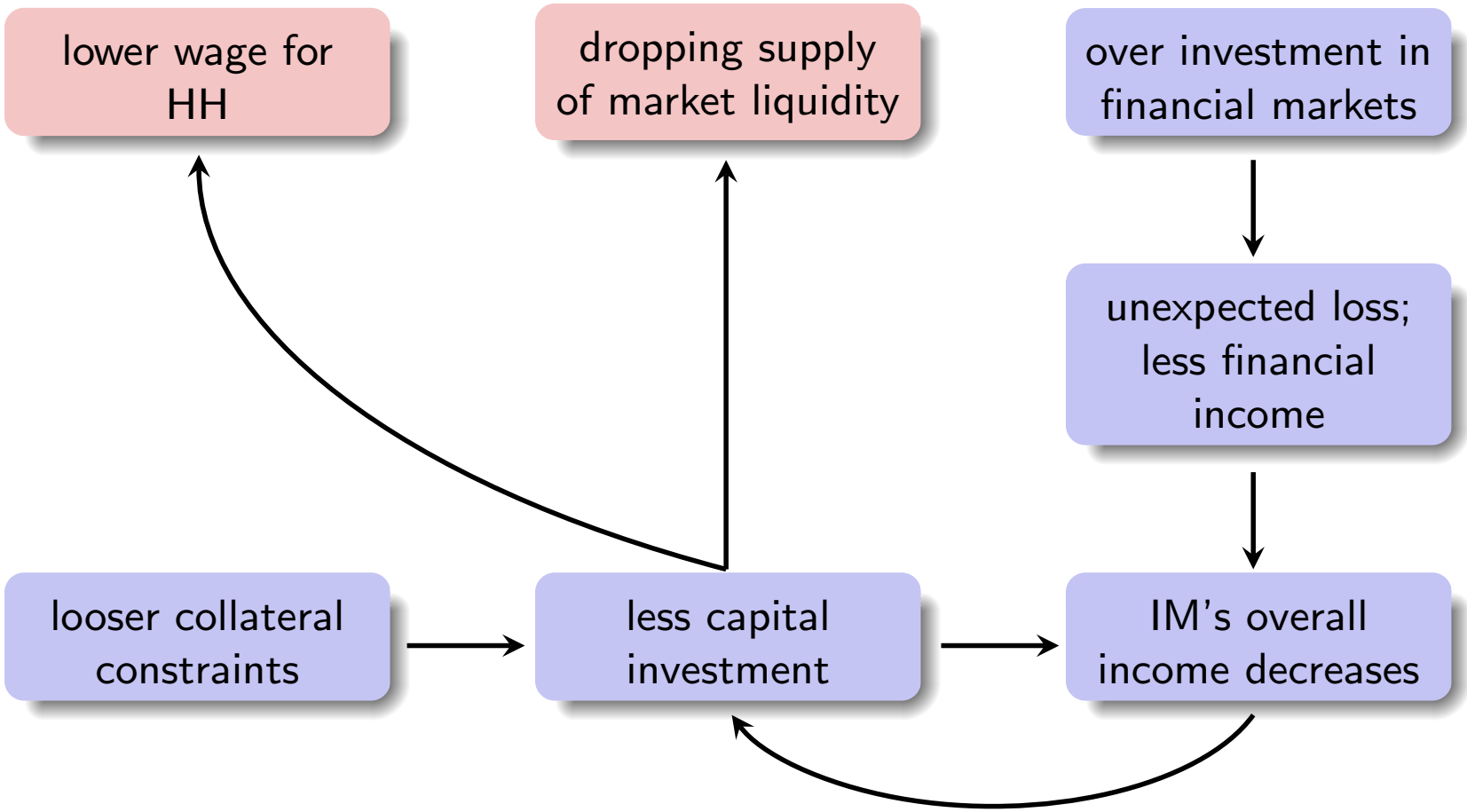

Risky Arbitrage – Tighter Collateral Constraints

overestimate case

- tighter collateral constraints
- underinvestment in financial markets
- higher income for both IM and HH
- stabilize the economy by boosting production at the cost of market liquidity

Policy Implication

with overheated financial market and shrinking production sector,

- tightening collateral constraints
  - alternative exogenous collateral constraints
  - independent of estimate over future prices

Extensions

- heterogeneous belief between IM and HH (Ally Q Zhang 2015)
  - information friction
  - HH's emotional trading
  - IM's misjudgement of HH's estimate
- segmented production (Ally Q Zhang 2016)
  - local production, local collateral
  - heterogeneous financial frictions
  - impact on foreign investment, market liquidity and local employment

Q&A

Thank you!