Macro, Money and Finance

Lecture 01: Introduction

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Motivation

- Aim: Bridge the gap between
  - Macro/monetary research
  - Finance research

- Financial sector helps to
  - overcome financing frictions and
  - channels resources
  - creates money

  … but
  - Credit crunch due to adverse feedback loops & liquidity spirals
    - Non-linear dynamics

- New insights to monetary and international economics

Based on Brunnermeier, Eisenbach & Sannikov Econometric Society World Congress 2010 Brunnermeier & Reis

- Price stability
  Monetary policy
- Financial stability
  Macroprudential policy
- Fiscal debt sustainability
  Fiscal policy

- Short-term interest
- Policy rule (terms structure)

inter-action

- Reserve requirements
- Capital/liquidity requirements
- Collateral policy
  Margins/haircuts
- Capital controls

inter-action

Methodology

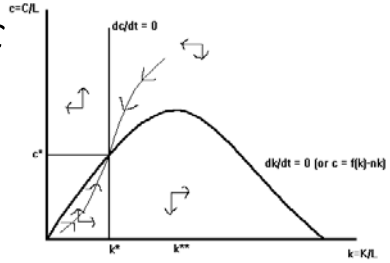
timeline

- *Verbal Reasoning* *(qualitative)*

Fisher, Keynes, …

Macro

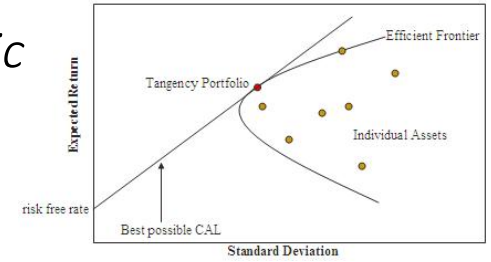
- Growth theory
  - *Dynamic (cts. time)*
  - *Deterministic*



- Introduce stochastic
  - *Discrete time*
    - Brock-Mirman, Stokey-Lucas
    - DSGE models

Finance

- Portfolio theory
  - *Static*
  - *Stochastic*



- Introduce dynamics
  - *Continuous time*
    - Options — Black Scholes
    - Term structure — CIR
    - Agency theory — Sannikov

- Cts. time macro with financial frictions

Pre-crisis Macro

- Price/wage rigidities
- Expectations of
  - cash flow
  - "the" short-term interest rate
  - Expectation hypothesis
  - Credit spread = expected default
- Euler equation
  - Substitution effects

Post-crisis Macro&Finance

- Financial frictions
- Endogenous risk/volatility
  e.g. runs, sudden stops, …
- Risk premia time varying
  - Term risk premia
  - Credit risk premia
- Wealth redistribution
  - Income/wealth effect

$$\Delta \text{price} = f(\Delta E[\text{future cash flows}], \Delta \text{risk premia})$$

Risk premium news the main driver

Heterogeneous Agents & Frictions

- Lending-borrowing/insuring since agents are different

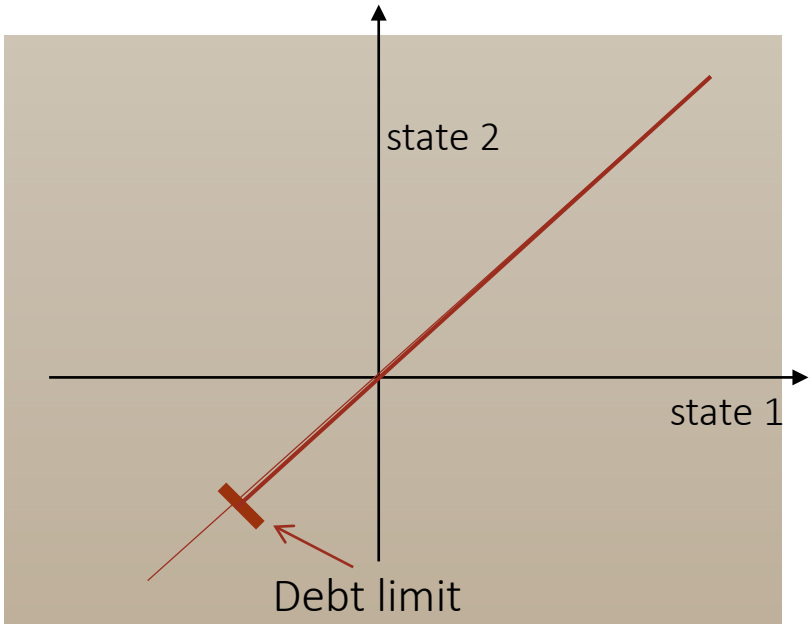
▪ Poor-rich ▪ Productive ▪ Less patient ▪ Less risk averse ▪ More optimistic	Limited direct lending due to frictions ⟷	▪ Rich-poor ▪ Less productive ▪ More patient ▪ More risk averse ▪ More pessimistic

- Friction $\longrightarrow$ $p_s MRS_s$ different even after transactions

- Wealth distribution matters! (net worth of subgroups)
- Financial sector is not a veil

Types of Distortions

- Belief distortions
  - Match "belief surveys" *(BGS)*
- Incomplete markets
  - "natural" leverage constraint *(BruSan)*
  - Costly state verification *(BGG)*
- + Leverage constraints
  (no "liquidity creation")
  - Exogenous limit *(Bewley/Ayagari)*
  - Collateral constraints
    - Next period's price *(KM)*
      $$Rb_t \leq q_{t+1} k_t$$
    - Next periods volatility *(VaR, JG)*
    - Current price
- Search Friction *(DGP)*



can depend on prices/volatilit

Course on continuous time macro

1. Introduction: Liquidity, Run-up, Crisis-Amplification, Recovery

Real Macro-Finance Models with Heterogeneous Agents

2. A Simple Model
3. General Solution Technique
4. International Macro-Finance Model with Sudden Stops/Runs

Money Models

5. A Simple Money Model
6. General Solution Technique
7. The I Theory of Money
8. Welfare Analysis & Optimal Policy
   - Monetary and Macroprudential Policy
9. International Financial Architecture*
10. Robust Computational Methods – Comparing Nonlinear Models
11. Calibration and Empirical Implications

Overview: Financial Crises

- Run-up phase
  - Distorted Beliefs
  - Concentration of Risk
  - Maturity Shortening
- Crash phase
  - Fire-sales
  - Paradox of Prudence
  - Spillovers
- Recovery phase
  - Persistence vs. Resilience
  - Dynamic Amplification
  - Volatility Dynamics/Volatility Paradox

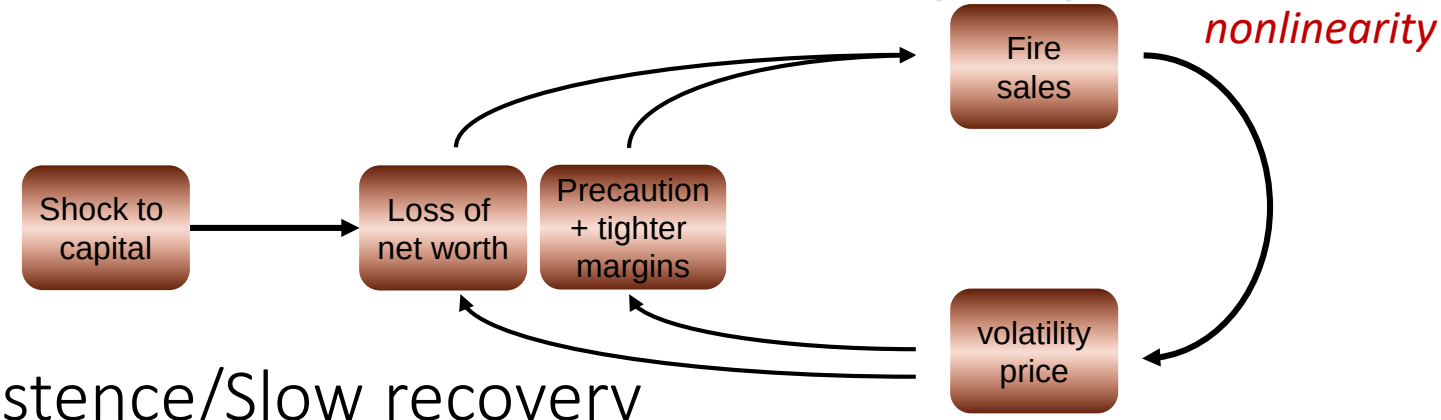
Externalities

Strategic Complements/Substitutes

The 2 Components of Systemic Risk

1. Systemic risk build-up during (credit) bubble
   … and materializes in a crisis — *– time-series*
   - "Volatility Paradox" → contemp. measures inappropriate
   - Vulnerability focus instead of timing focus

2. Spillovers/contagion — *– cross sectional*
   - Direct contractual: domino effect – *network*
   - Indirect: price effect (fire-sale externalities)
     credit crunch, *liquidity* spirals



3. Persistence/Slow recovery

preventive

crisis management

The 2 Components of Systemic Risk

1. Systemic risk build-up during (credit) bubble
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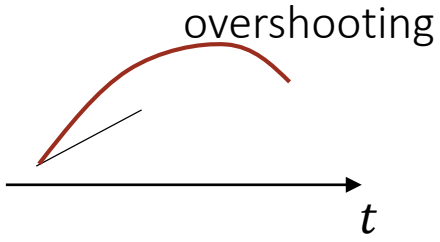
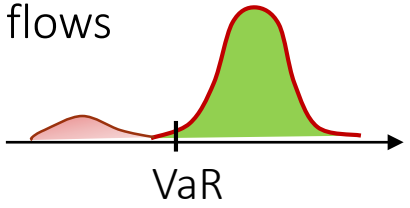
crisis management preventive

Run-up 1: Bubbles due to Beliefs "Distortions"

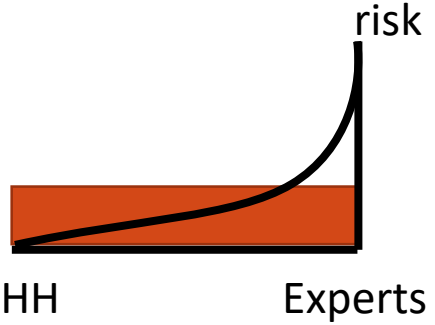


- Extrapolative Expectations
  - Representativeness heuristic
  - Overestimate of productivity after good shock
  - Bubbles/overinvestment driven by *level of beliefs* a la Miller (1977)
    - AS: Surveys consistent with each other, mutual fund flows
  - Local thinking "neglect of tail risk" ≈ VaR



- Heterogeneous beliefs: optimists and pessimists
  - + limited commitment ⇒ Leverage cycle
  - "Marginal buyer" vary with shocks
  - Surveys elicit "consensus beliefs" ≠ marginal buyer's beliefs
- Switching heterogeneous beliefs ⇒ Speculation
  (Resale option a la Harrison-Kreps/Scheinkman-Xiong):
  - optimist/pessimist "switching" + short-sale constraint
  - ⇒ Bubbles, volatility, and transaction volume

Run-up 2: Concentration of Risk



- Financial frictions models:
  - "Experts" hold most of aggregate risk in good times
  - Low volatility, but risk builds up in background
  - Credit cycle: (BGG/KM/BruSan)
  - Leverage cycle: (JG/BruPed) extreme leverage in cts. time limit

Run-up 3: Maturity Mismatch

- Brunnermeier-Oehmke: Maturity “rat race”
  - Incentive to dilute creditors
- Diamond-Dybvig: Demand for liquidity
- Calomiris-Kahn: Discipline for banker

Run-up 3: Maturity Mismatch

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Run-up 4: Build-up of Interlinkages

- Kopytov (2018)

Run-up 5: Build-up Strategic Complementarity

- In payoffs externalities

$$\frac{\partial u^i}{\partial x^{-i}}$$

  - If others sell, I suffer a negative shock
  - Pecuniary externalities
    - Incomplete markets setting
    - Price affects collateral constraint
  - Normative theory (welfare implications)

- In response strategic substitutes/complements

$$\frac{\partial \frac{\partial u^i}{\partial x^i}}{\partial x^{-i}}$$

  - If others sell, it is more profitable for me to also sell
  - Descriptive/positive theory

Run-up 5: Build-up Strategic Complementarity

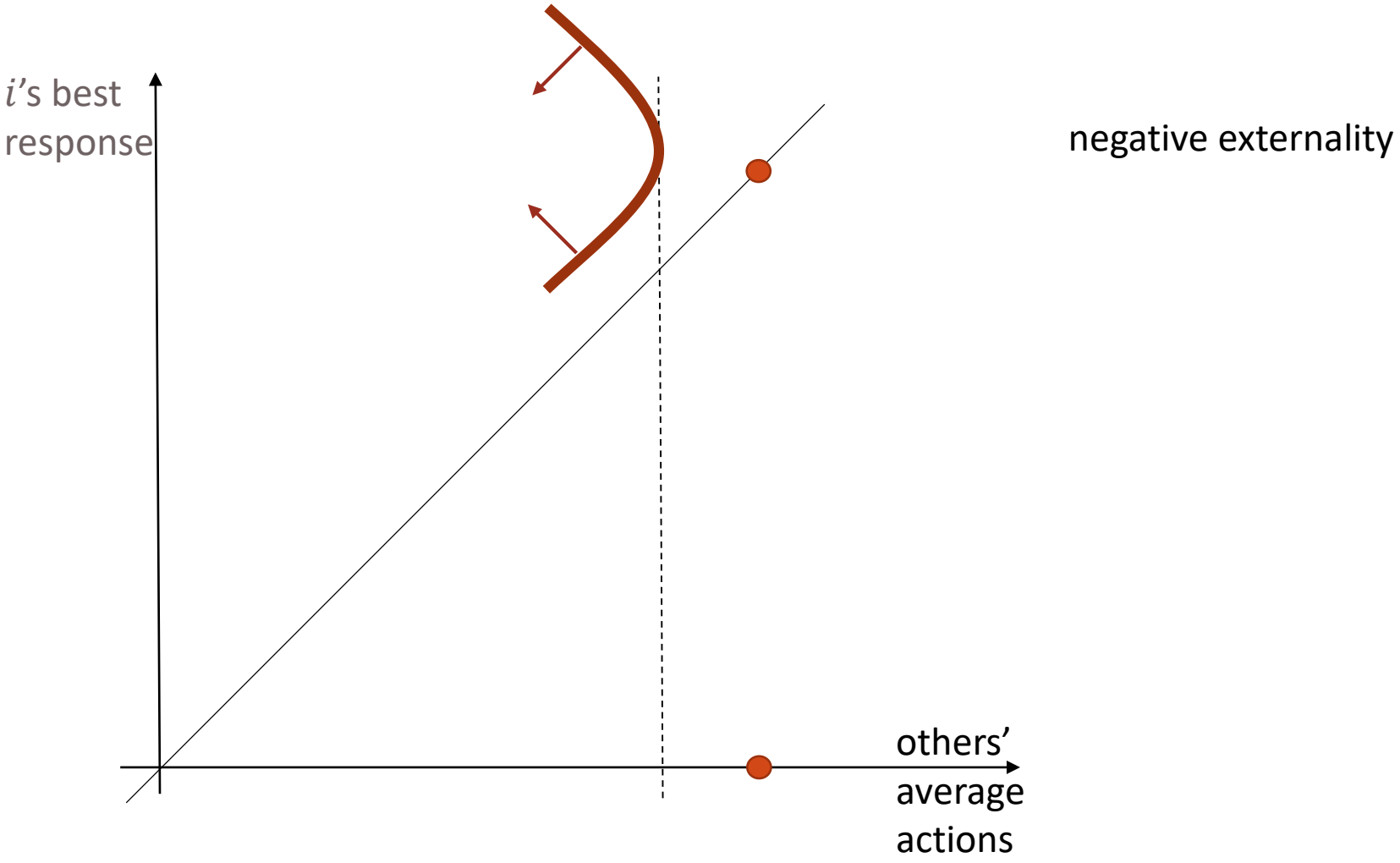
- A “strategic-substitute-externality”

  (we Germans like long words ☺)

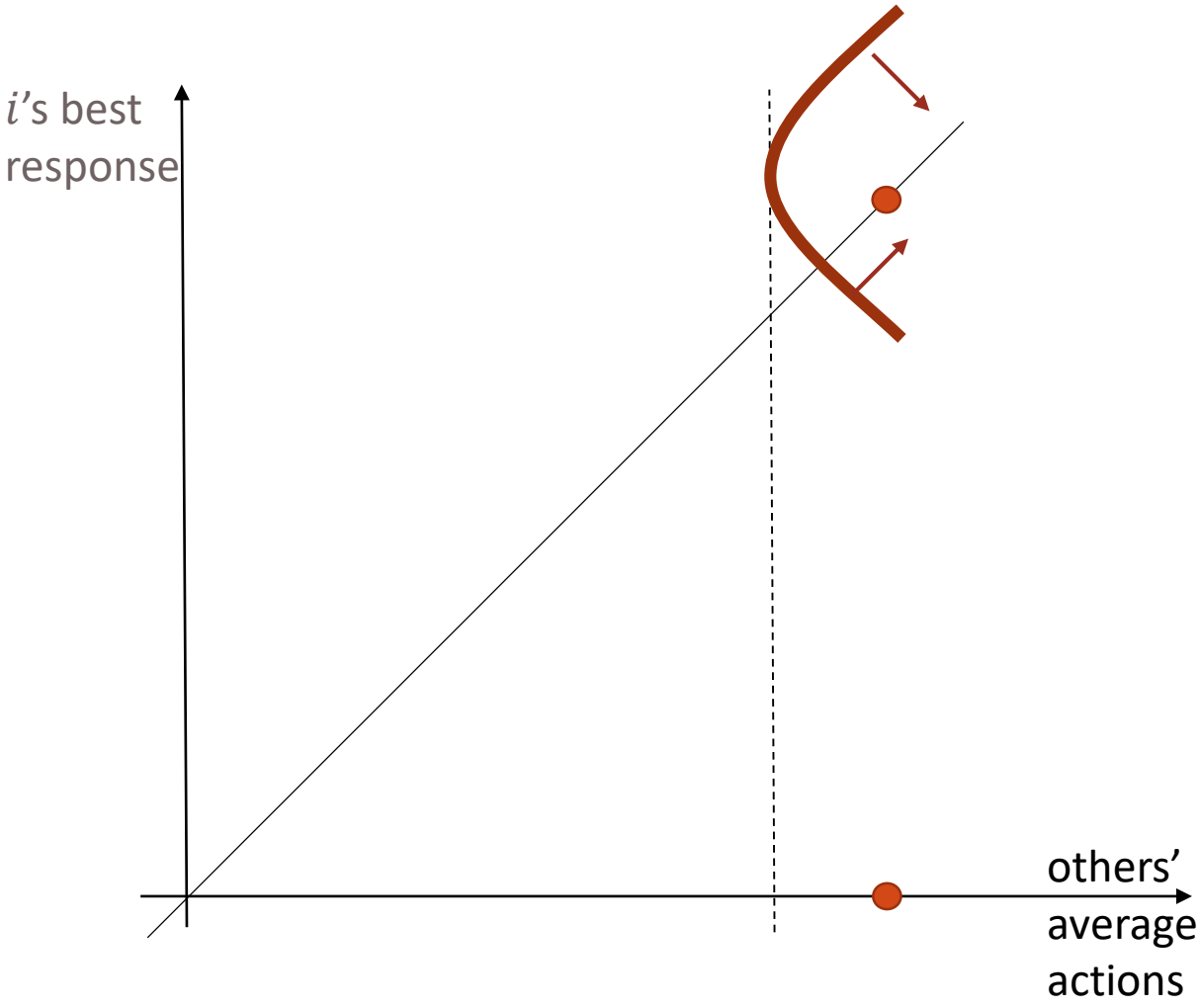
  - Externality:
    individual ignores that his action leads to a build-up of strategic complementarities
    - With potential large price swings/fire sales

    - Pecuniary externality: e.g. fire-sale externality

Externality: negative

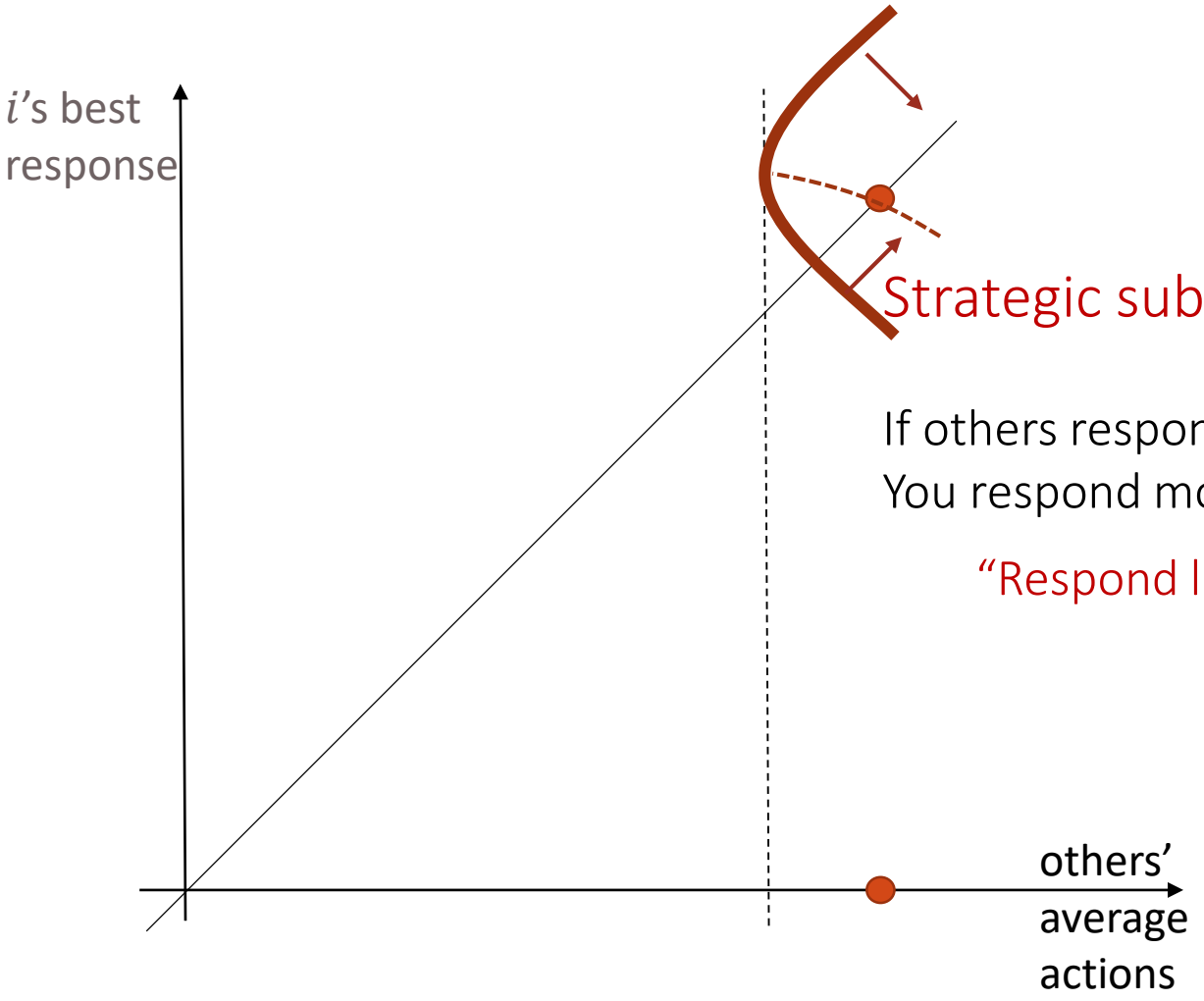


Externality: positive



Positive externality

Strategic substitutability

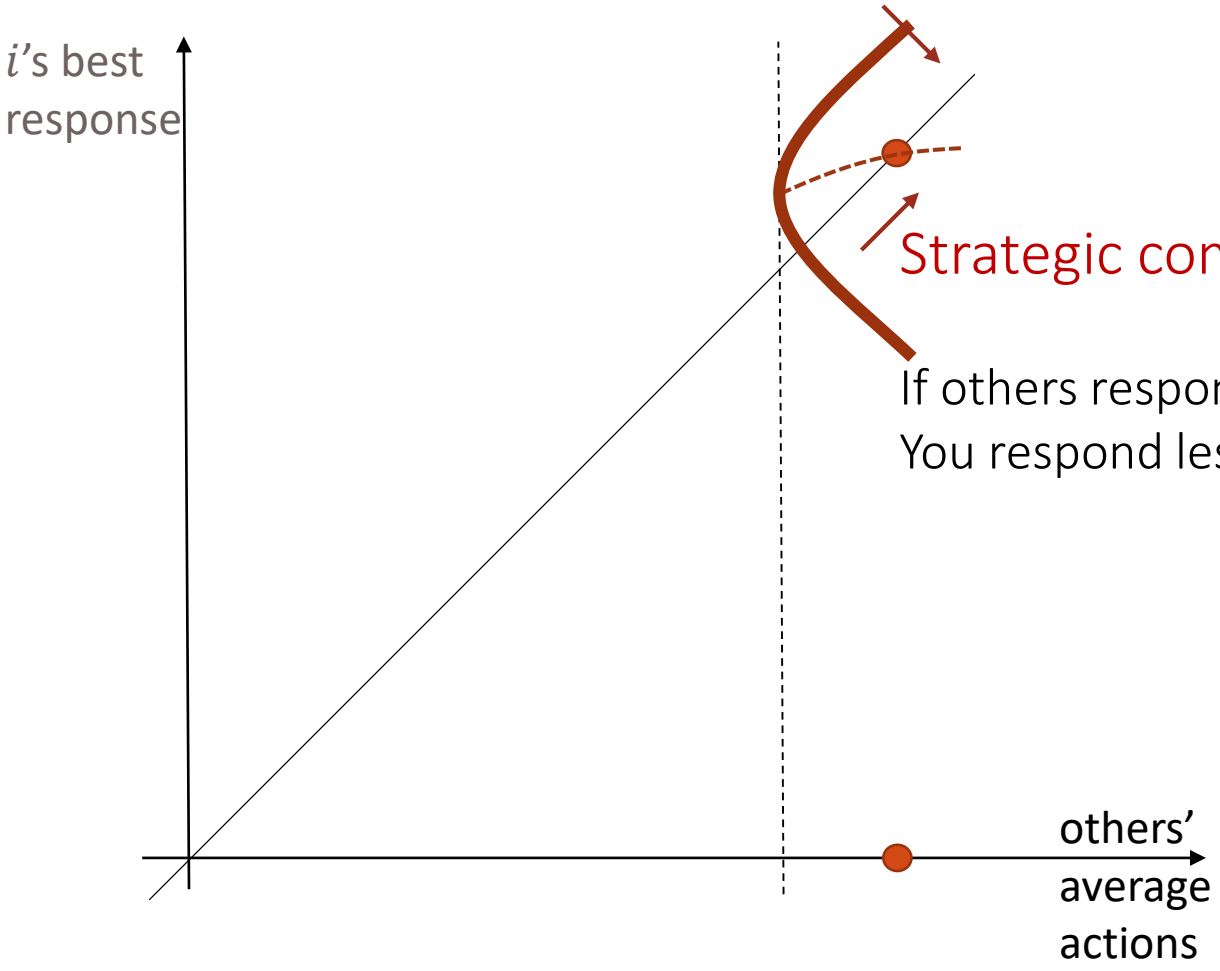


Strategic substitutability

If others respond less, (price goes down)
You respond more (buy more)

"Respond like a maverick"

Strategic Complementarity



Strategic complementarity

If others respond less, (price goes down)
You respond less (buy less)

Externalities vs. Strategic Complemetarities

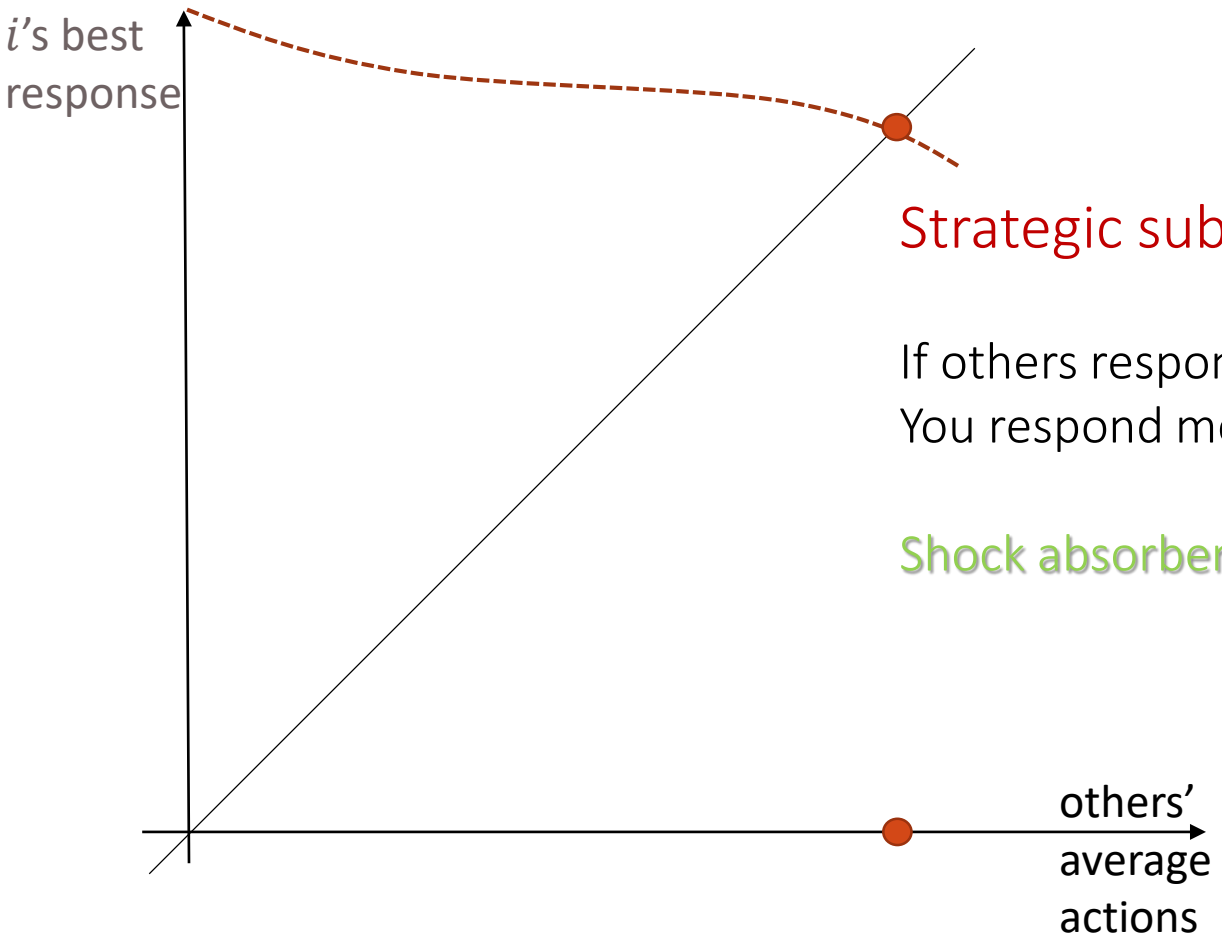
- Externalities (payoff spillovers) $\frac{\partial u^i}{\partial x^{-i}}$

and

- Strategic Complementarity/Substitutability $\frac{\partial \frac{\partial u^i}{\partial x^i}}{\partial x^{-i}} = \frac{\partial \frac{\partial u^i}{\partial x^{-i}}}{\partial x^i}$
  - can be independent of each other
  - …but note: if $\frac{\partial u^i}{\partial x^{-i}} = 0$, then $\frac{\partial \frac{\partial u^i}{\partial x^i}}{\partial x^{-i}} = 0$

- Connection:
  - Due to strategic complementarities x^{-i} changes a lot
  - Which causes large externality (spillover)

Shock prior to run-up of imbalances



Strategic substitutability

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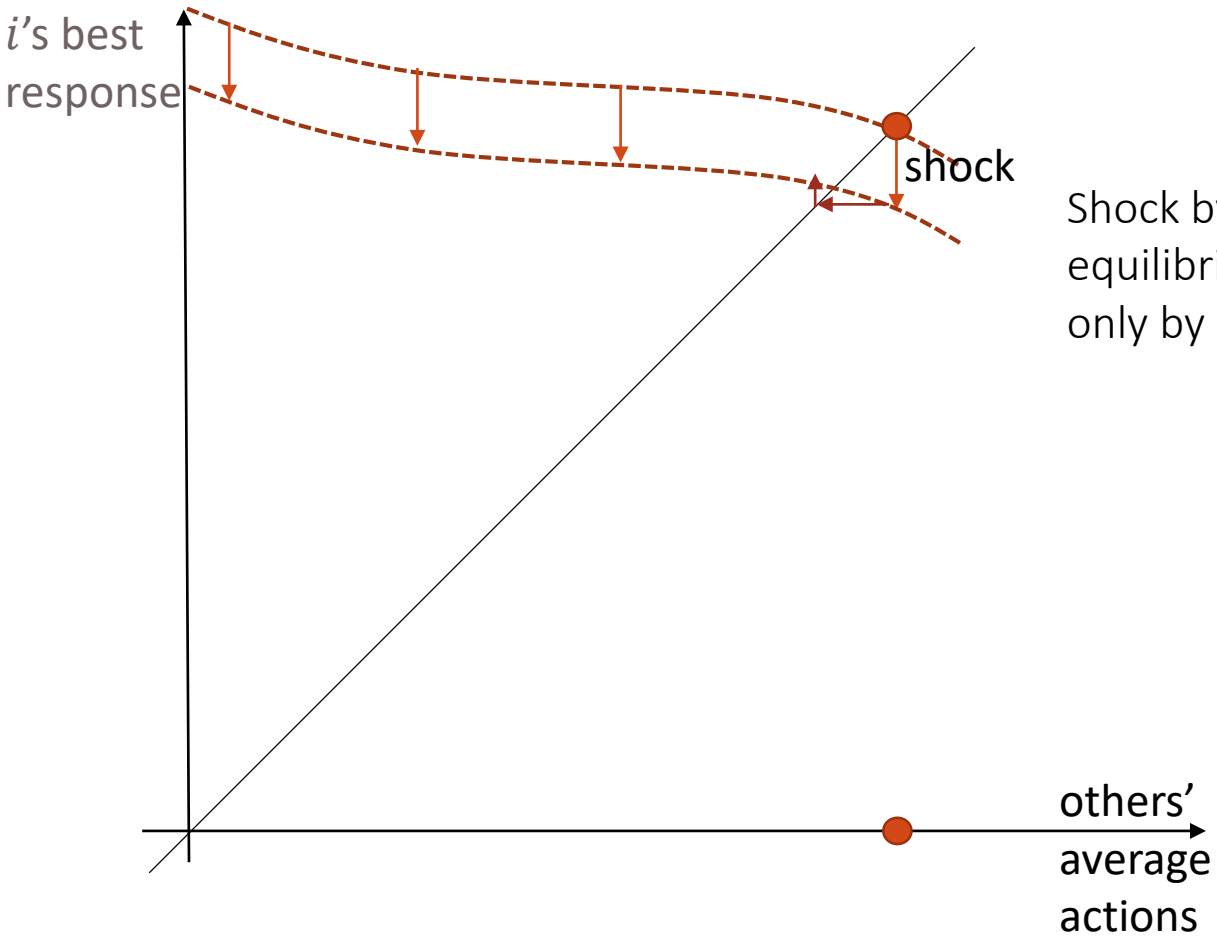
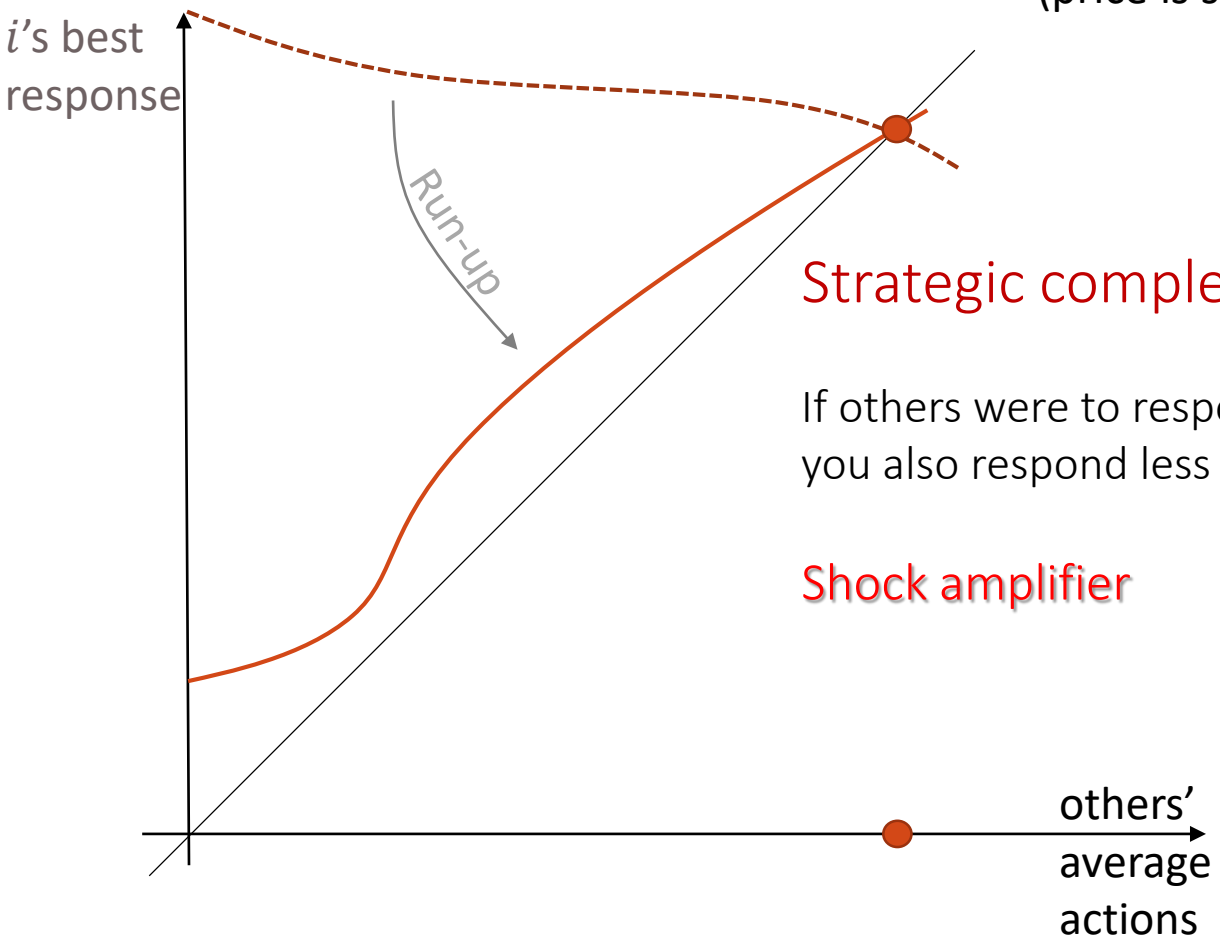
Shock absorber

Shock prior to run-up of imbalances



Shock by 10, but equilibrium declines only by 9

Run up of imbalances



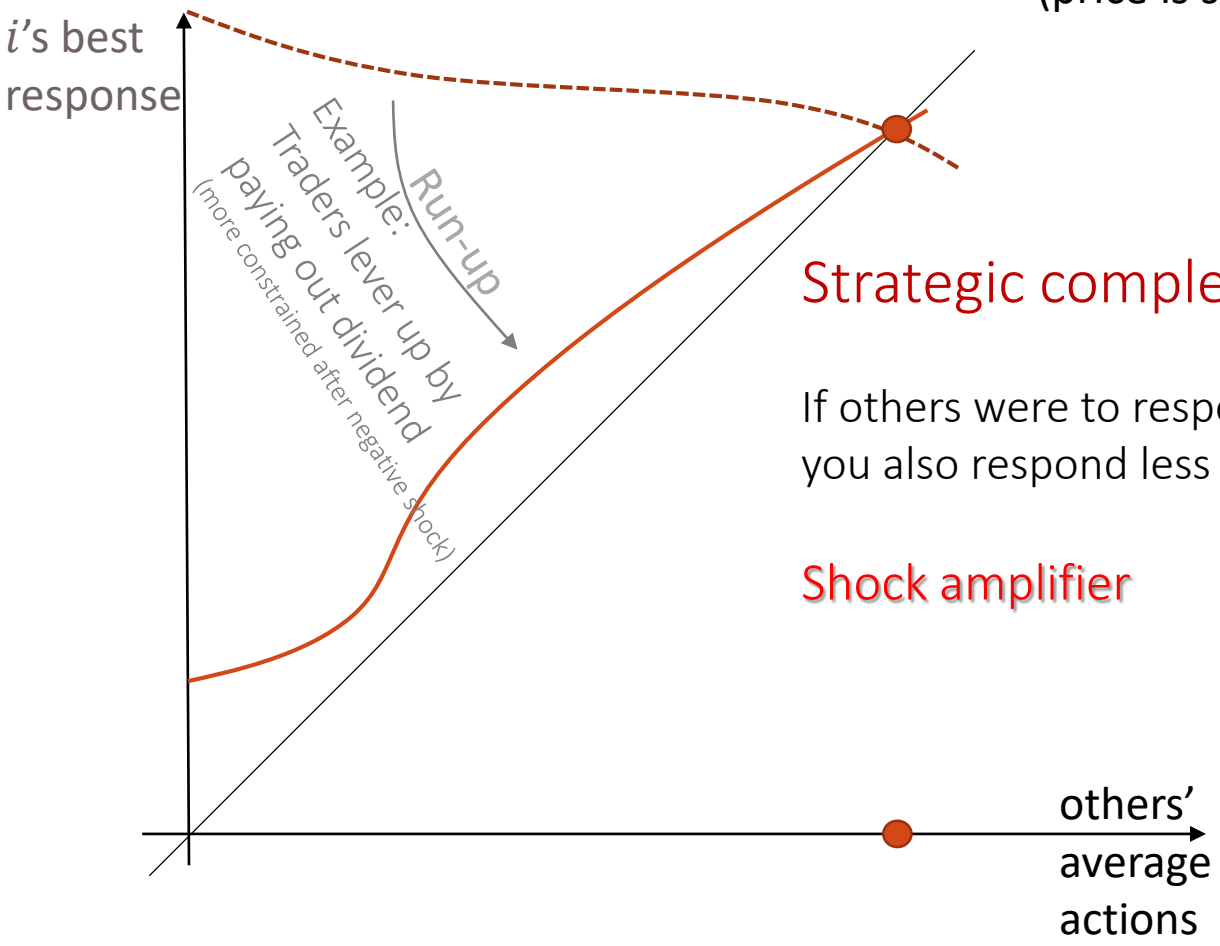
Only off equilibrium changes
(price is still high, but …)

Strategic complementarities

If others were to respond less, (price goes down)
you also respond less (buy less/sell)

Shock amplifier

Run up of imbalances



Only off equilibrium changes
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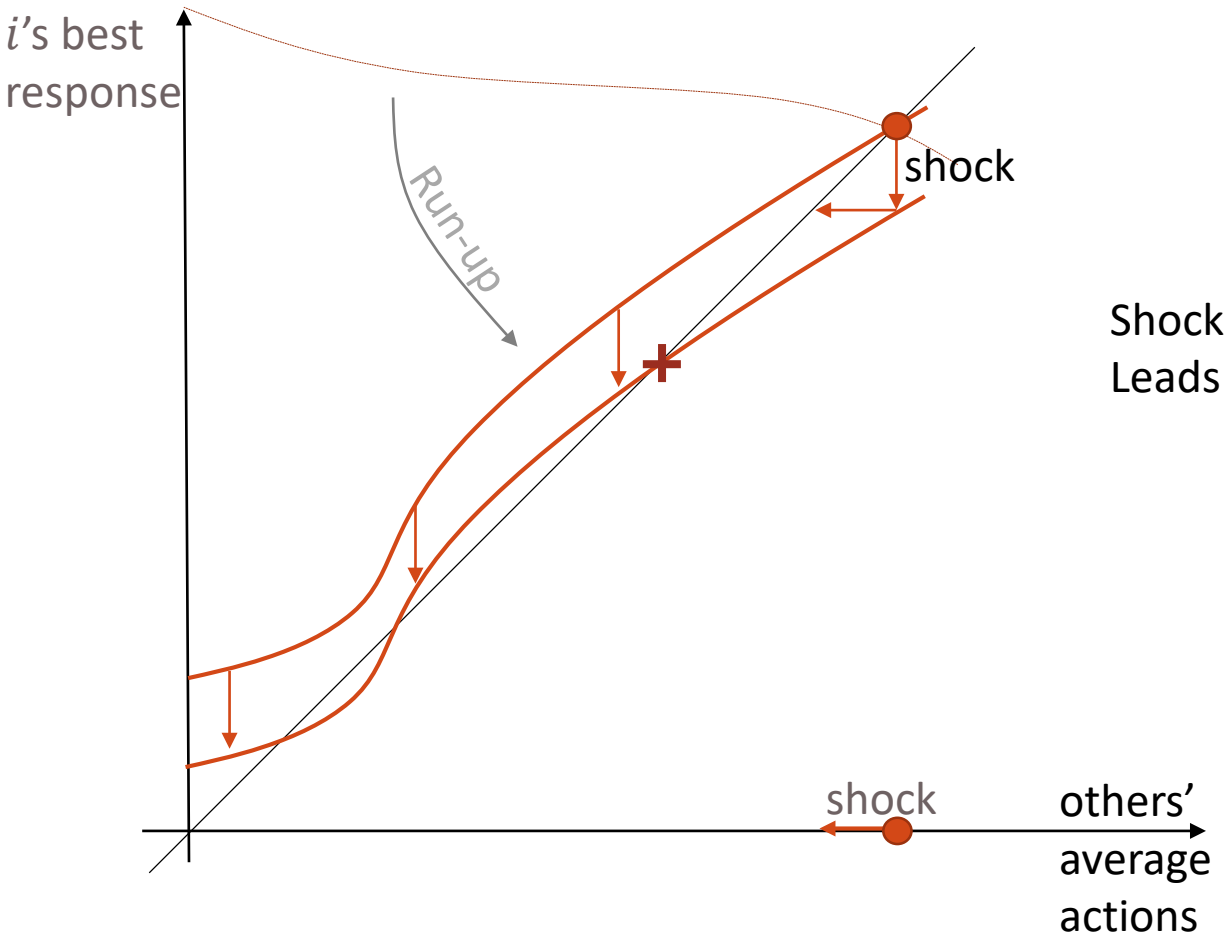
Shock amplifier

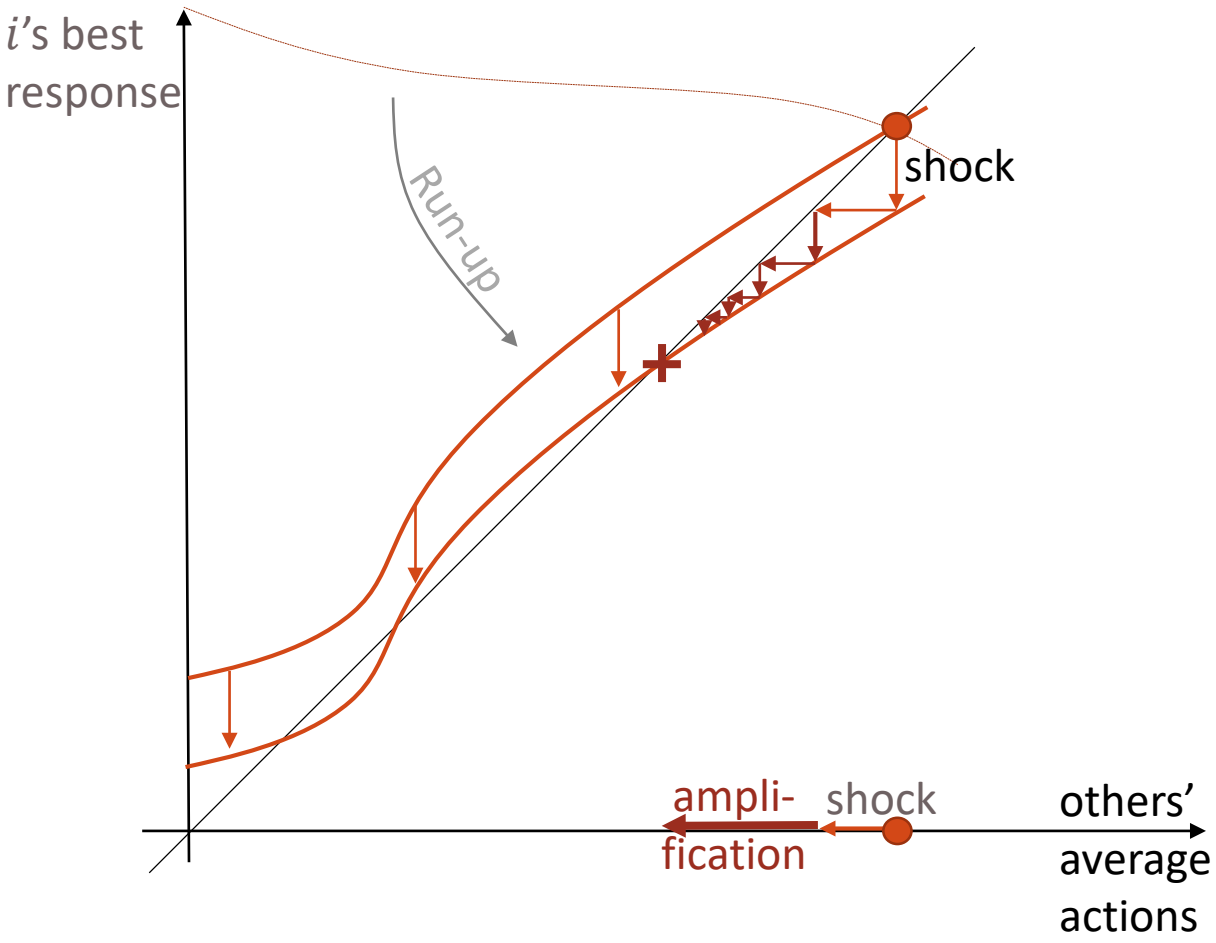
Shock after run-up



Shock by 10
Leads to equilibrium effect of 30

2nd, 3rd round effects: Amplification

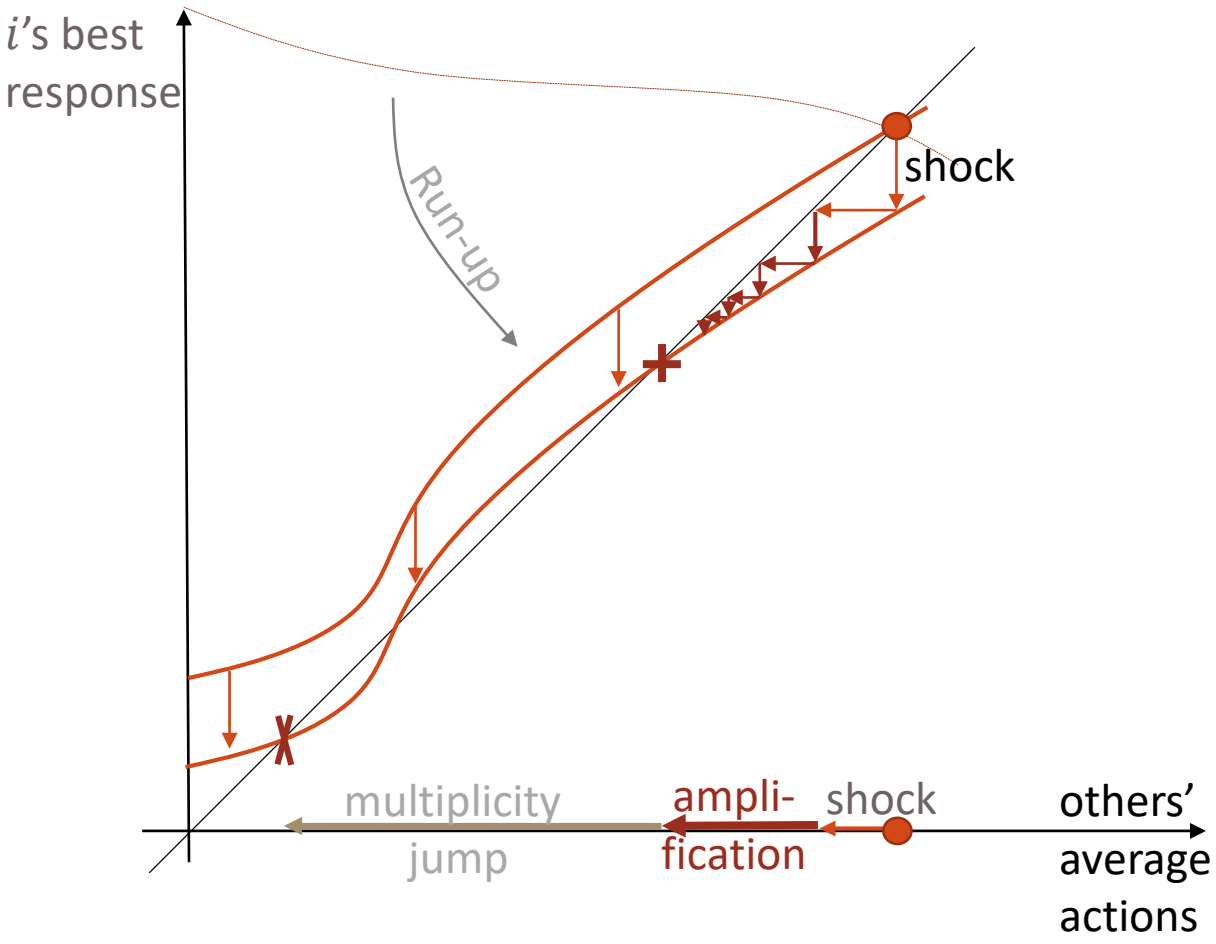
Initial fundamental shock/trigger is amplified



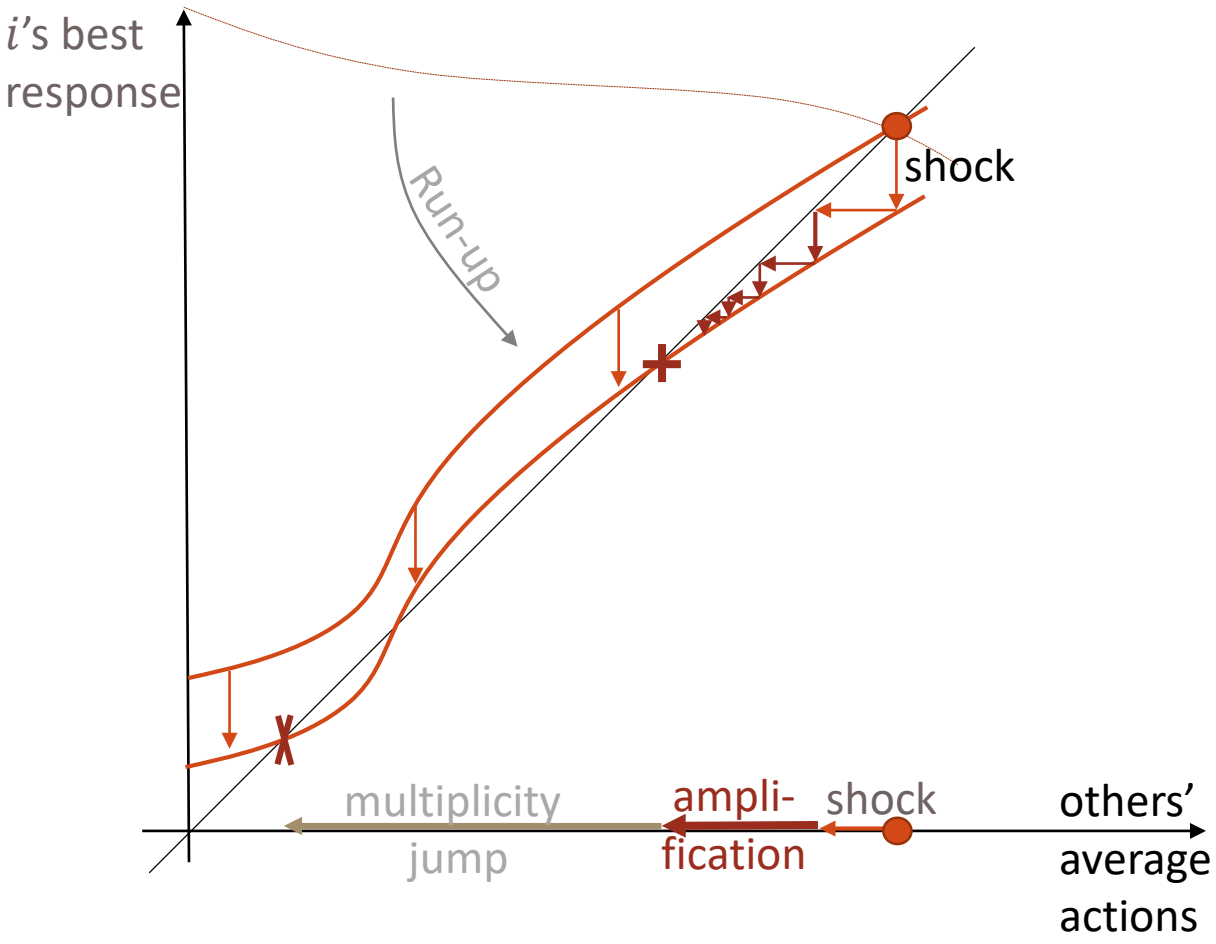
Amplification of Fundamental Shock

Multiplicity: without Fundamental Shock

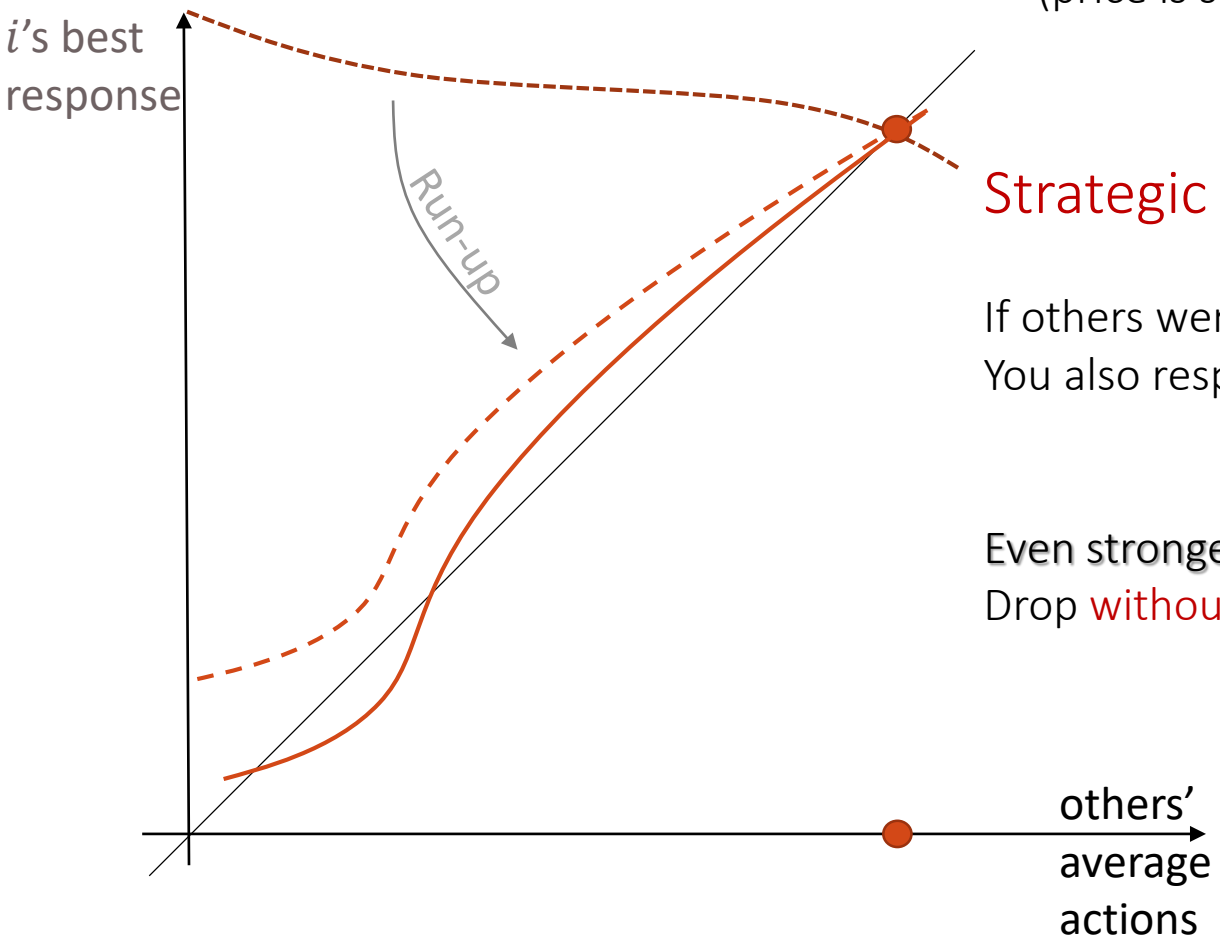
2nd, 3rd round effects: Amplification Multiplicity



2nd, 3rd round effects: Amplification Multiplicity



Multiplicity – Crisis vulnerability without shock



Only off equilibrium changes
(price is still high, but …)

Strategic complementarities

If others were to respond less,
You also respond less

Even stronger (slope >1)
Drop without fundamental shock

Overview: Financial Crises

- Run-up phase
  - Distorted Beliefs
  - Concentration of Risk
  - Maturity Shortening
- Crash phase
  - Traditional Bank Runs
  - Modern Banks and Liquidity Spirals
  - Fire-sales
  - Spillovers
- Recovery phase
  - Persistence vs. Resilience
  - Dynamic Amplification
  - Volatility Dynamics/Volatility Paradox

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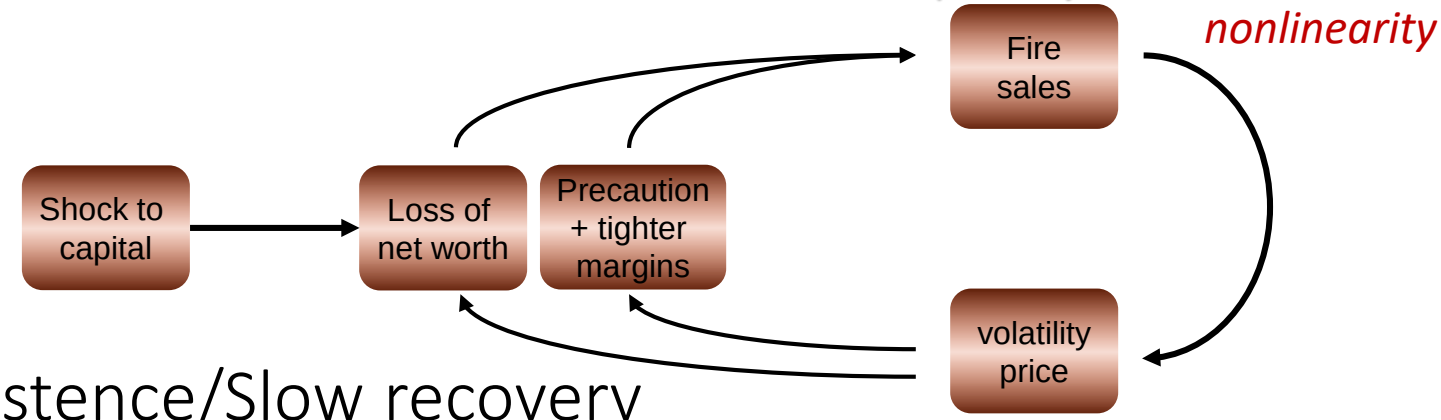
   - Indirect: price effect (fire-sale externalities)
     credit crunch, *liquidity* spirals

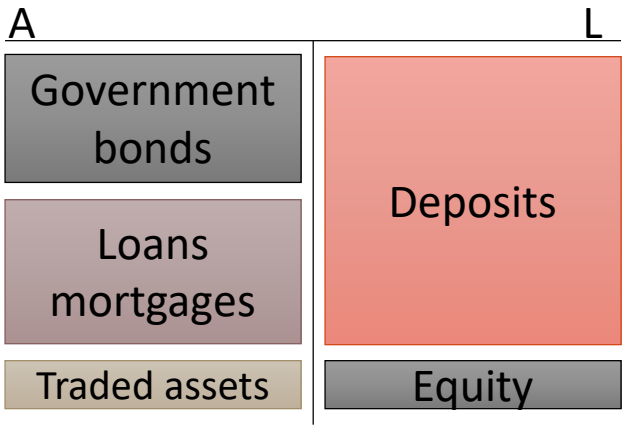


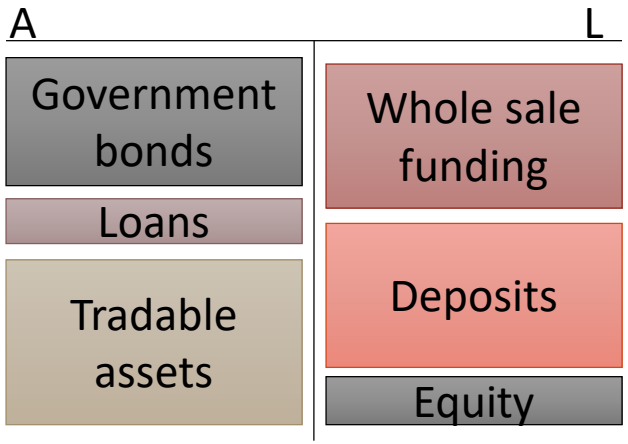
3. Persistence/Slow recovery

preventive

crisis management

Traditional vs. modern banks





- Bank run
  a la Diamond-Dybvig
  - … but inertia
    also due to demand deposit insurance

- Whole sale funding liq. risk
  like in Brunnermeier-Pedersen
  - Short-term
    No inertia
  - Collateralized

  Essentially senior

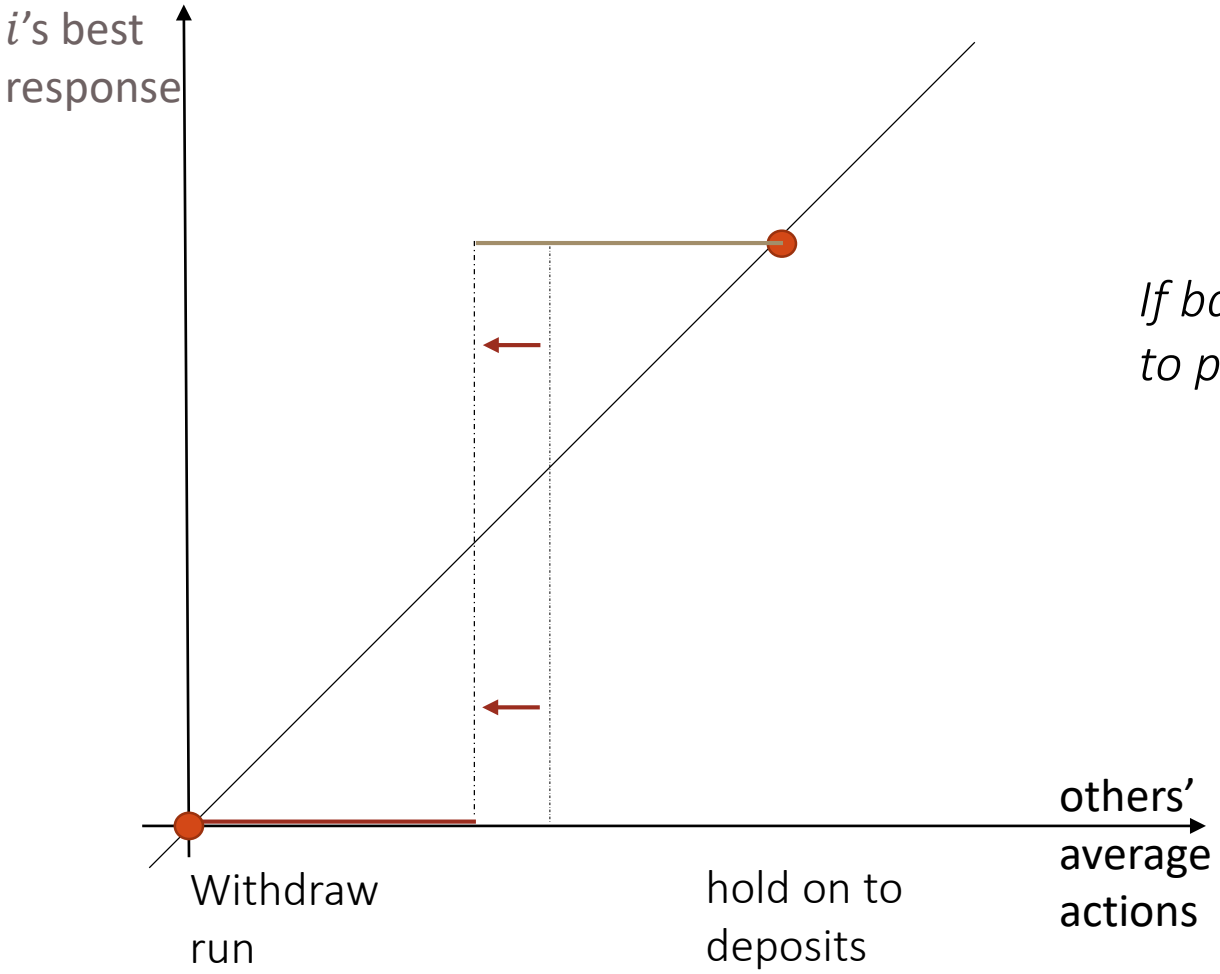
- Fire-sales of tradable assets
- Risk shifting towards depositors (insurance)

Bank Runs

+ Silent bank run (via internet)

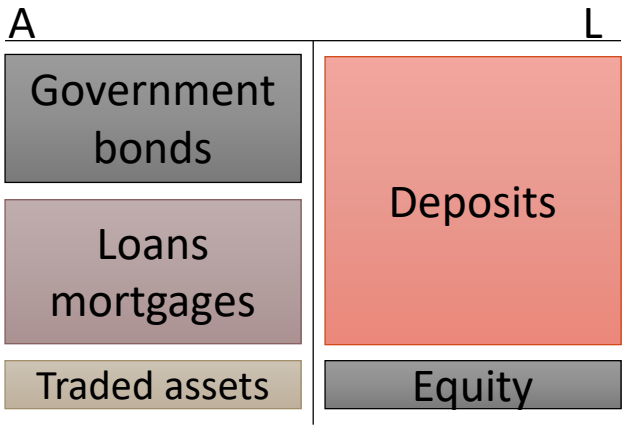
Example: Bank Run – Multiple Equilibria

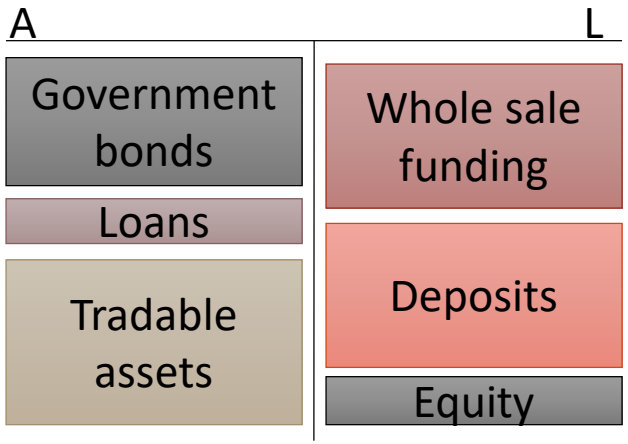
- Best response of agents at $t = 1$ who learned that they are "late consumers"



If bank issues extra equity to purchase liquid asset

Traditional vs. modern banks





- Bank run
  a la Diamond-Dybvig
  - Demand deposit
    - FDIC insurance -- inertia
  - Illiquid loans

- Whole sale funding liq. risk
  like in Brunnermeier-Pedersen
  - Short-term
    No inertia
  - Collateralized

  Essentially senior

- Fire-sales of tradable assets
- Risk shifting towards depositors (insurance)

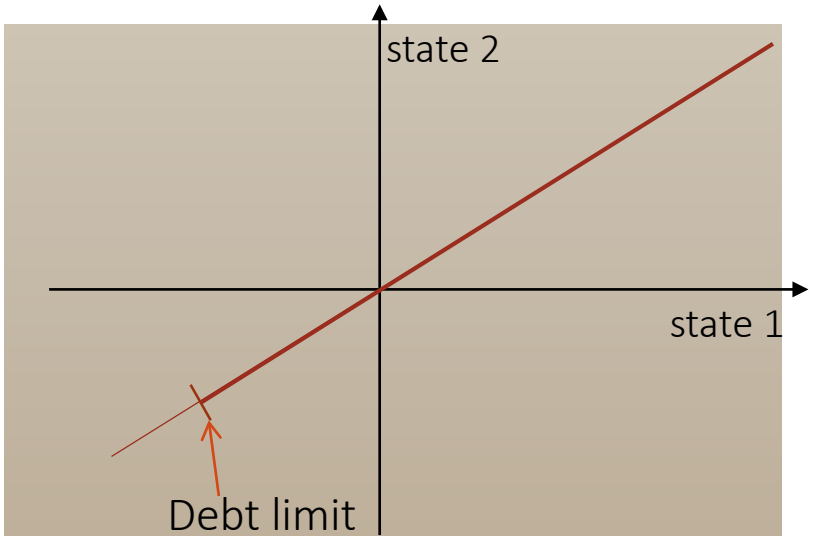
Financial Frictions

- Incomplete markets
  - E.g. only debt contracts due to adverse selection

- Leverage constraints
  - Exogenous limit (Bewley/Ayagari)
  - Collateral constraints
    - (Current price)
    - Next period's price (KM)

$$Rb_t \leq q_{t+1} k_t$$

    - Next periods volatility (VaR)



can depend on prices/volatility

Liquidity Concepts

- Financial instability arises from the fragility of liquidity

A | L

Market liquidity

- Specificity of capital
  Price impact of capital sale

Funding liquidity

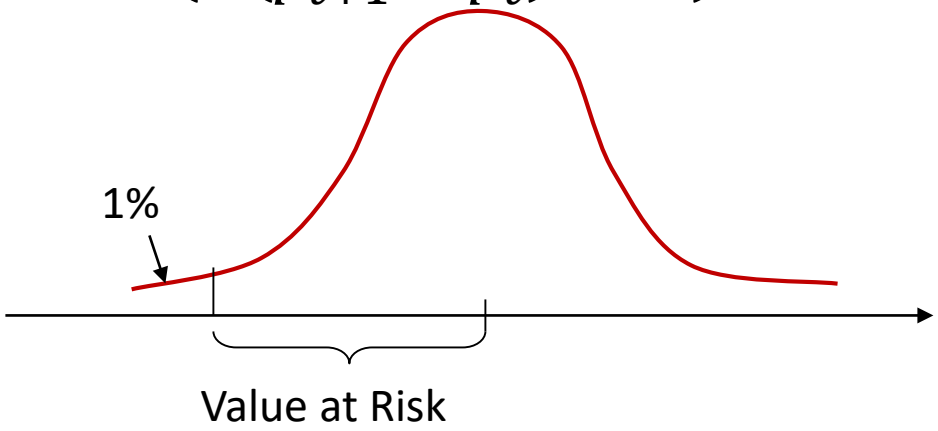
- Maturity structure of debt
  - Can't roll over short term debt
- Sensitivity of margins
  - Margin-funding is recalled

Liquidity
~~Maturity~~ mismatch

- *Liquidity mismatch* determines severity of amplification, (sunspot) runs, … "strategic complementarities"

Margins/Haircuts Spirals

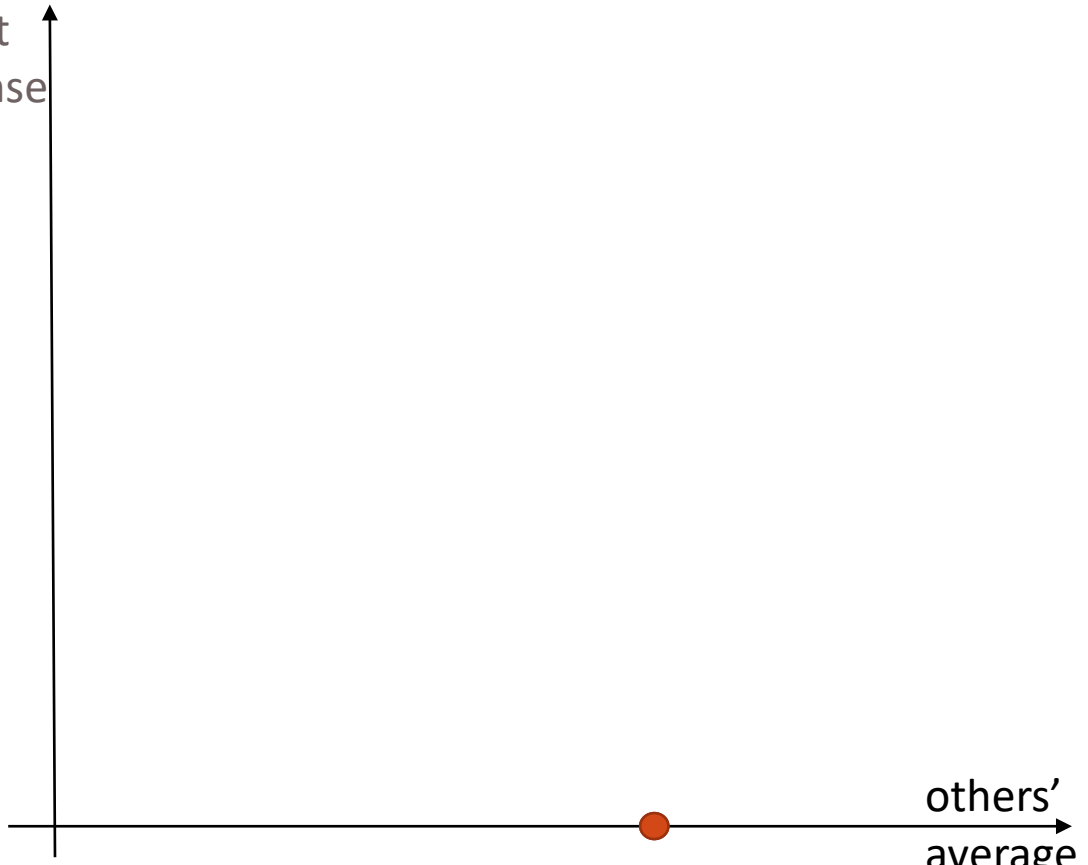
- How are margins set by brokers/exchanges?
  - **Value at Risk**: $\Pr(-(p_{t+1} - p_t) \geq m) = 1\% = \pi$



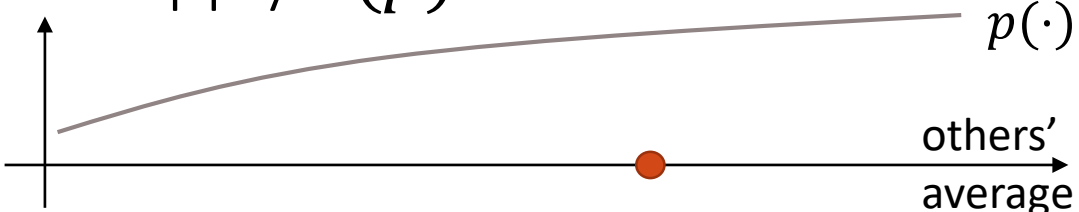
- For collateralized lending, debt constraints are directly linked to the volatility of collateral
  - Constraints are more binding in volatile environments
  - Feedback effect between volatility and constraints
- Margin spiral force agents to delever in times of crisis
  - Collateral runs counterparty bank run
  - Multiple equilibria

Leverage with Margin Funding

- action/holdings of "expert traders"



- residual supply $S(p)$



higher holding,
⇒ higher price

Leverage with Margin Funding

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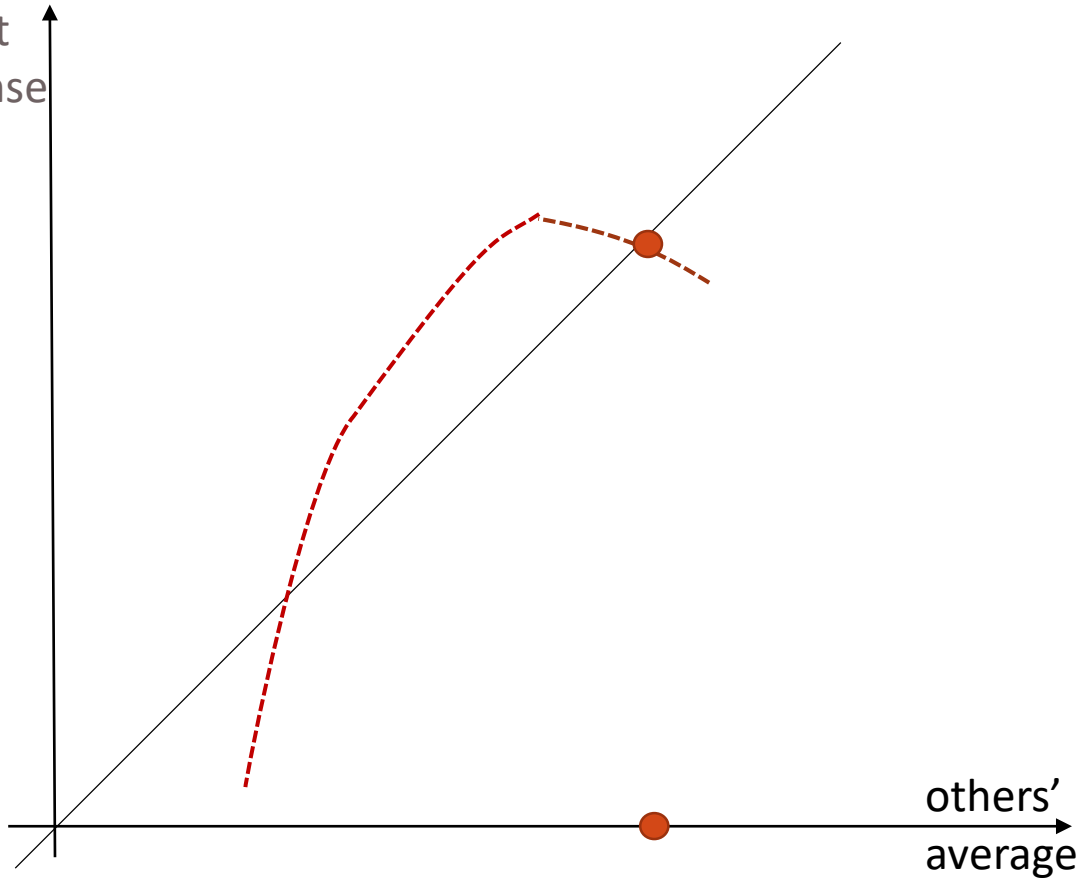

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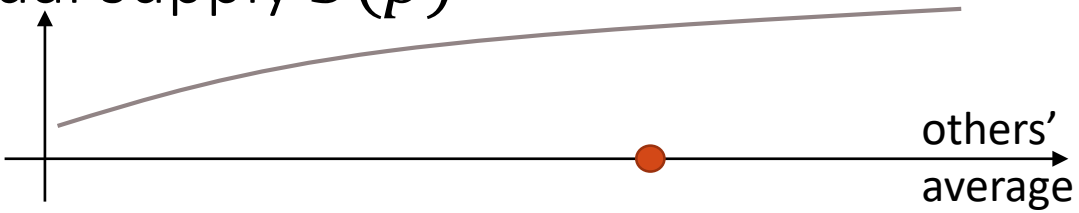

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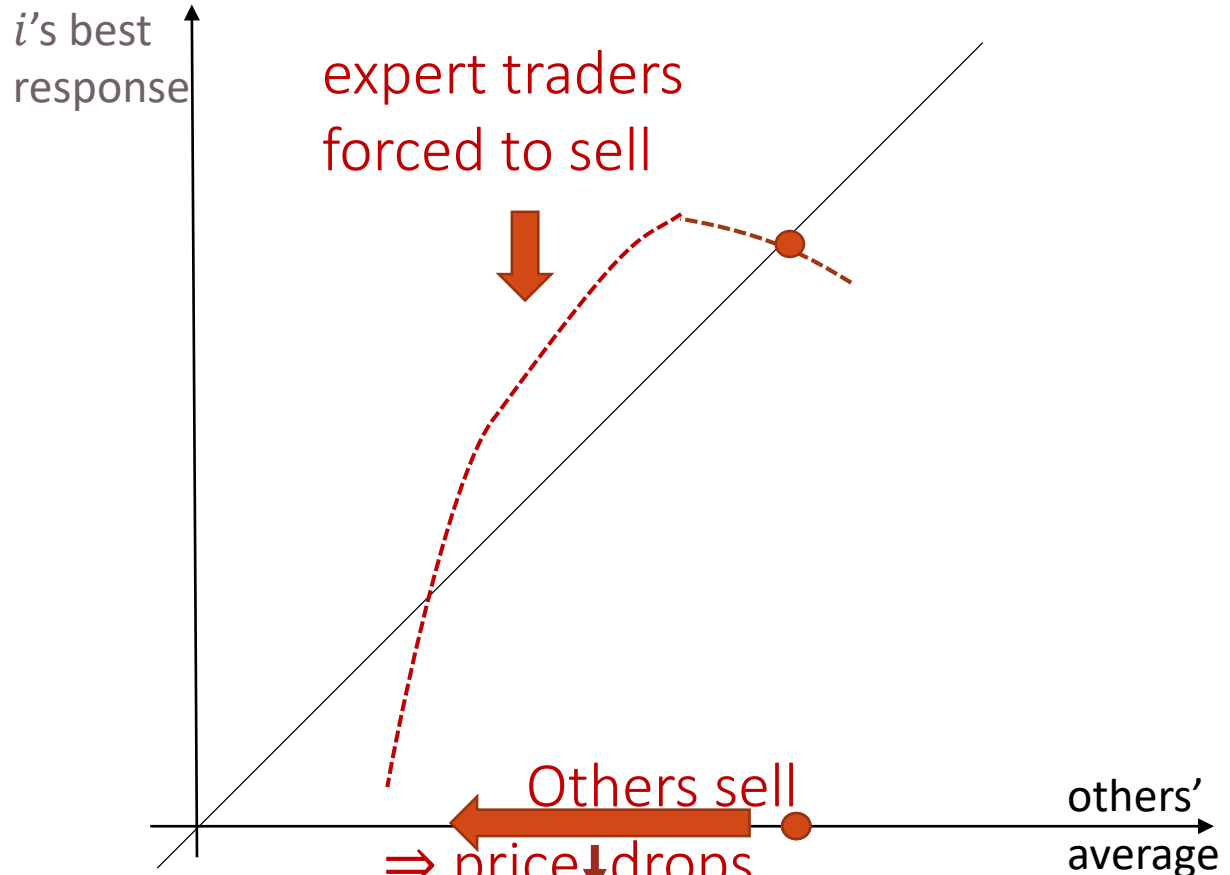
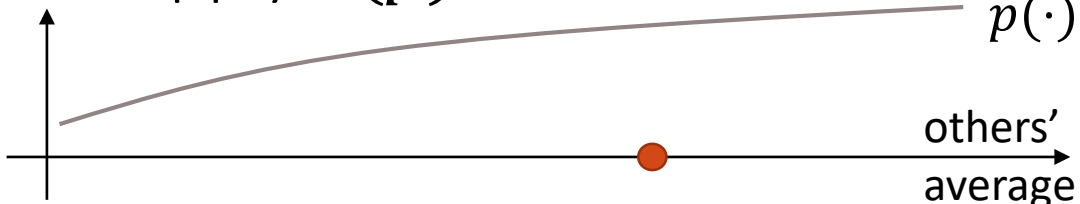
Leverage with Margin Funding

- action/holdings of "expert traders"



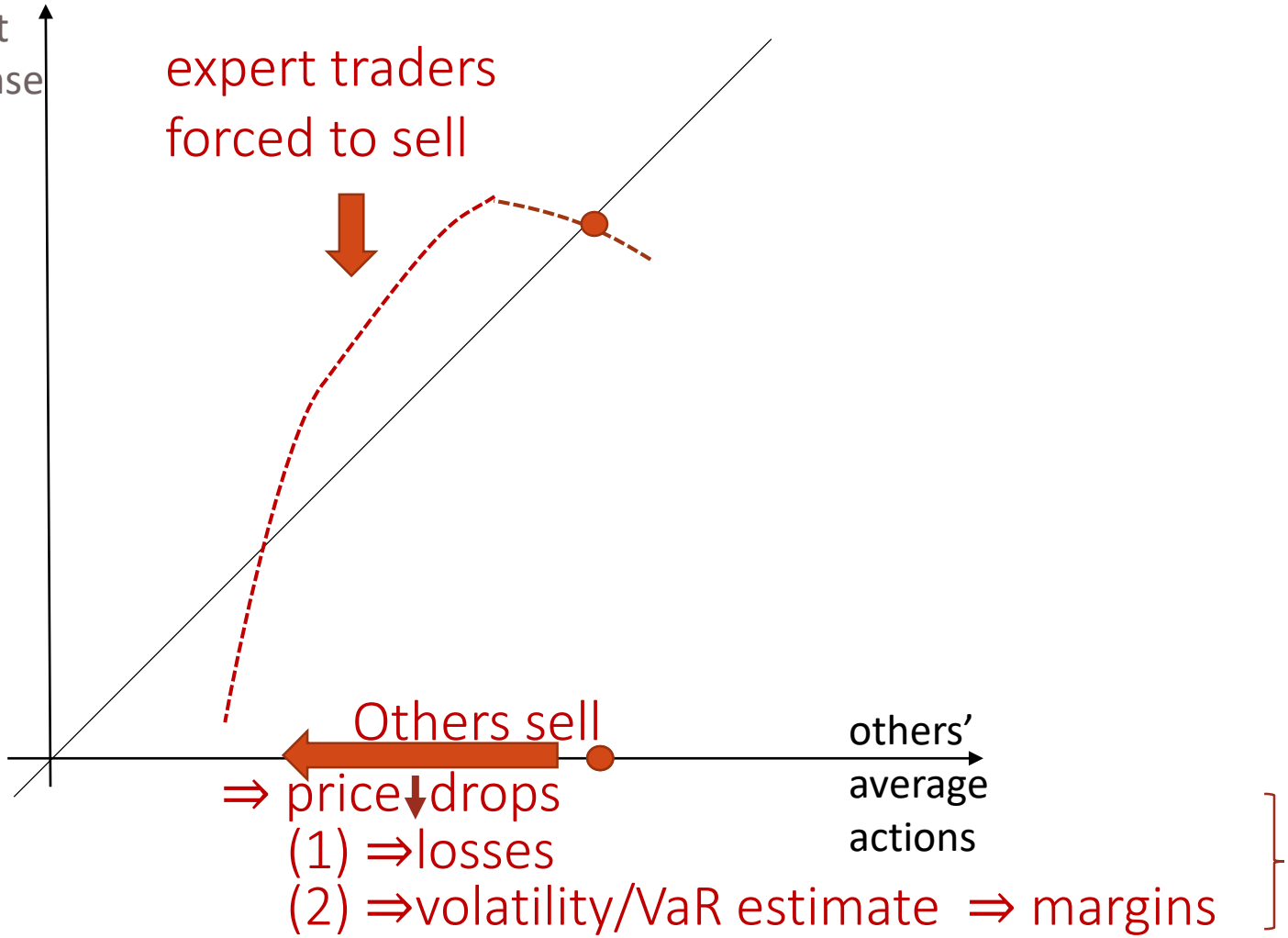
- residual supply $S(p)$



higher holding,
⇒ higher price

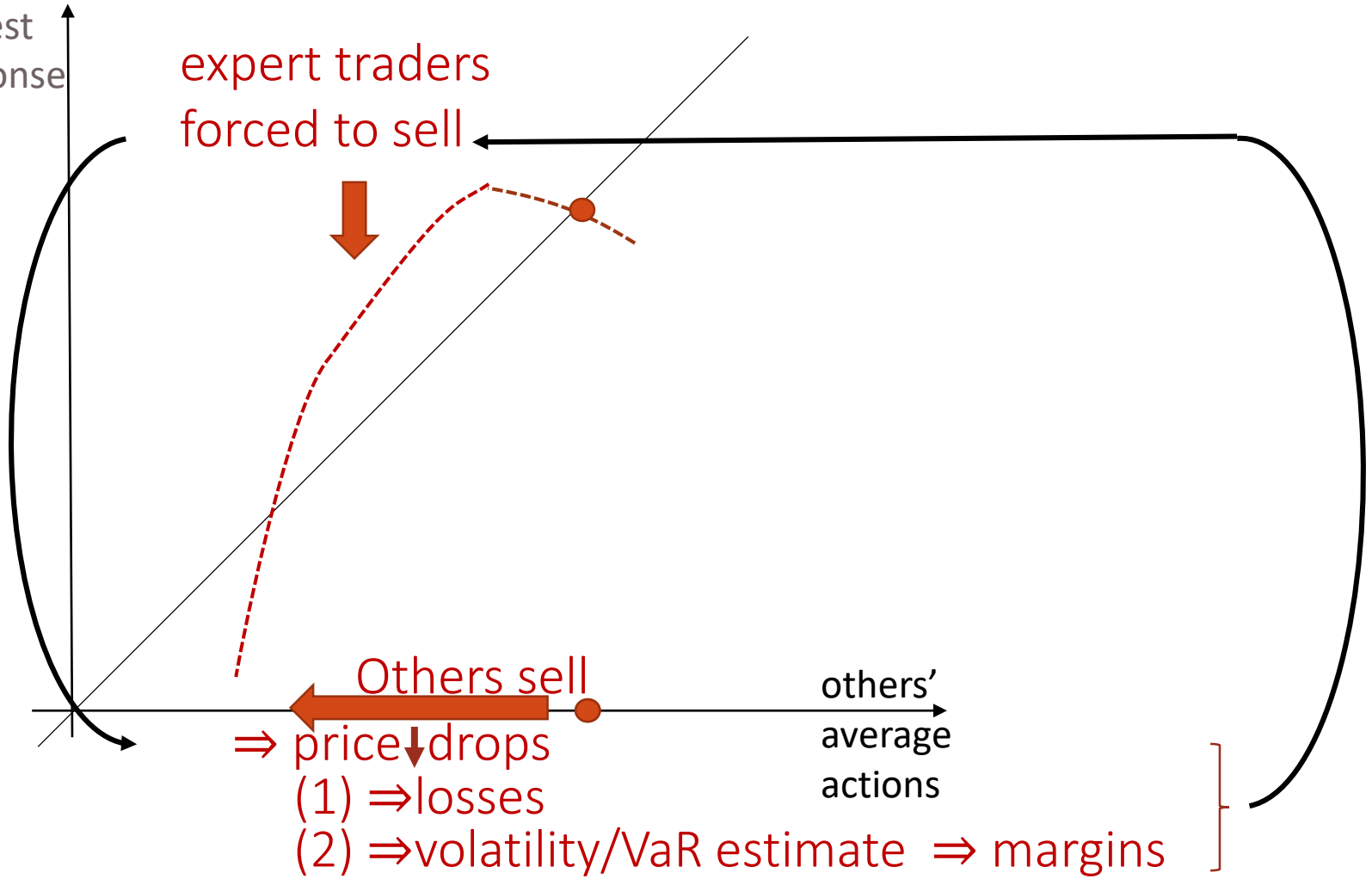
Leverage with Margin Funding

- action/holdings of "expert traders"



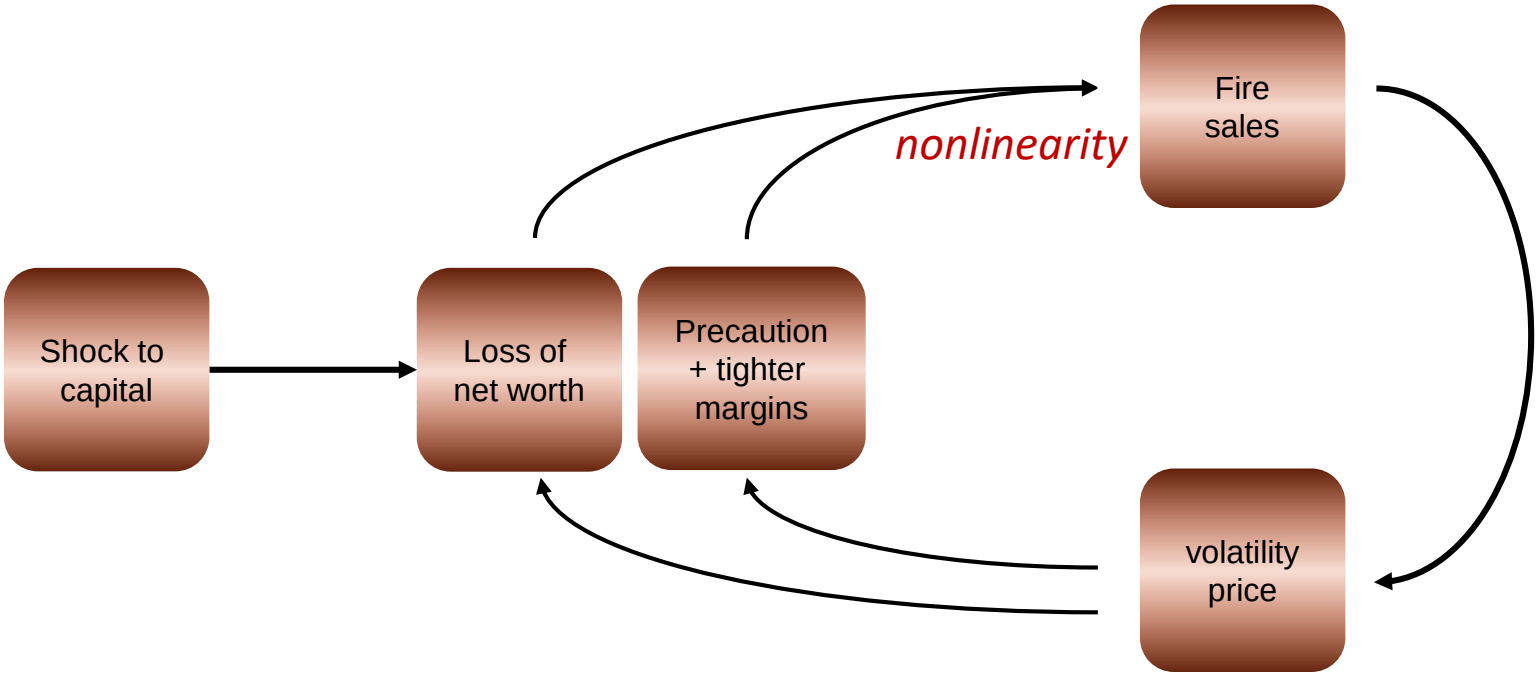
Leverage with Margin Funding

- action/holdings of "expert traders"



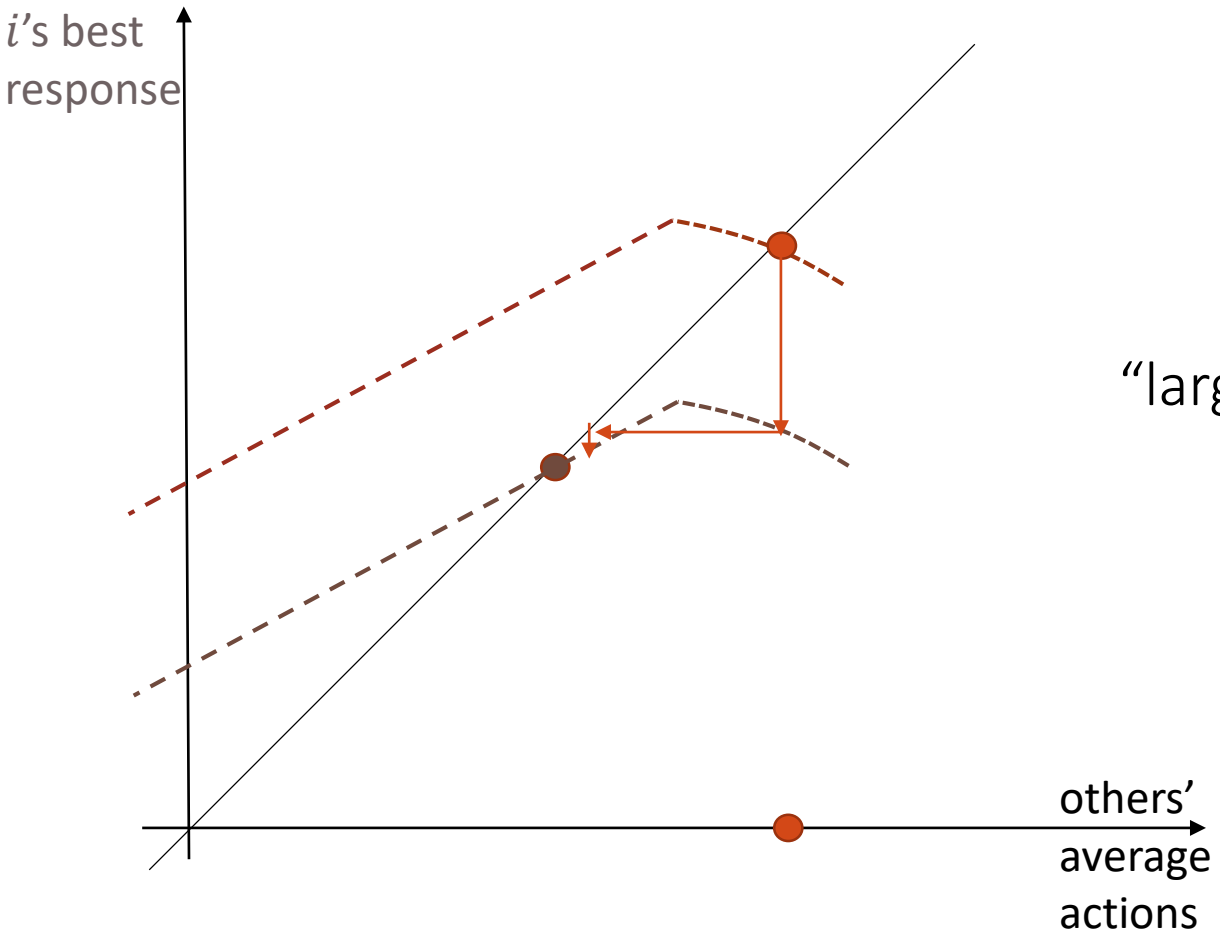
Liquidity Spirals – Amplification effects

- Loss Spiral
- Margin Spiral



Amplification/Destabilizing after Large Shock

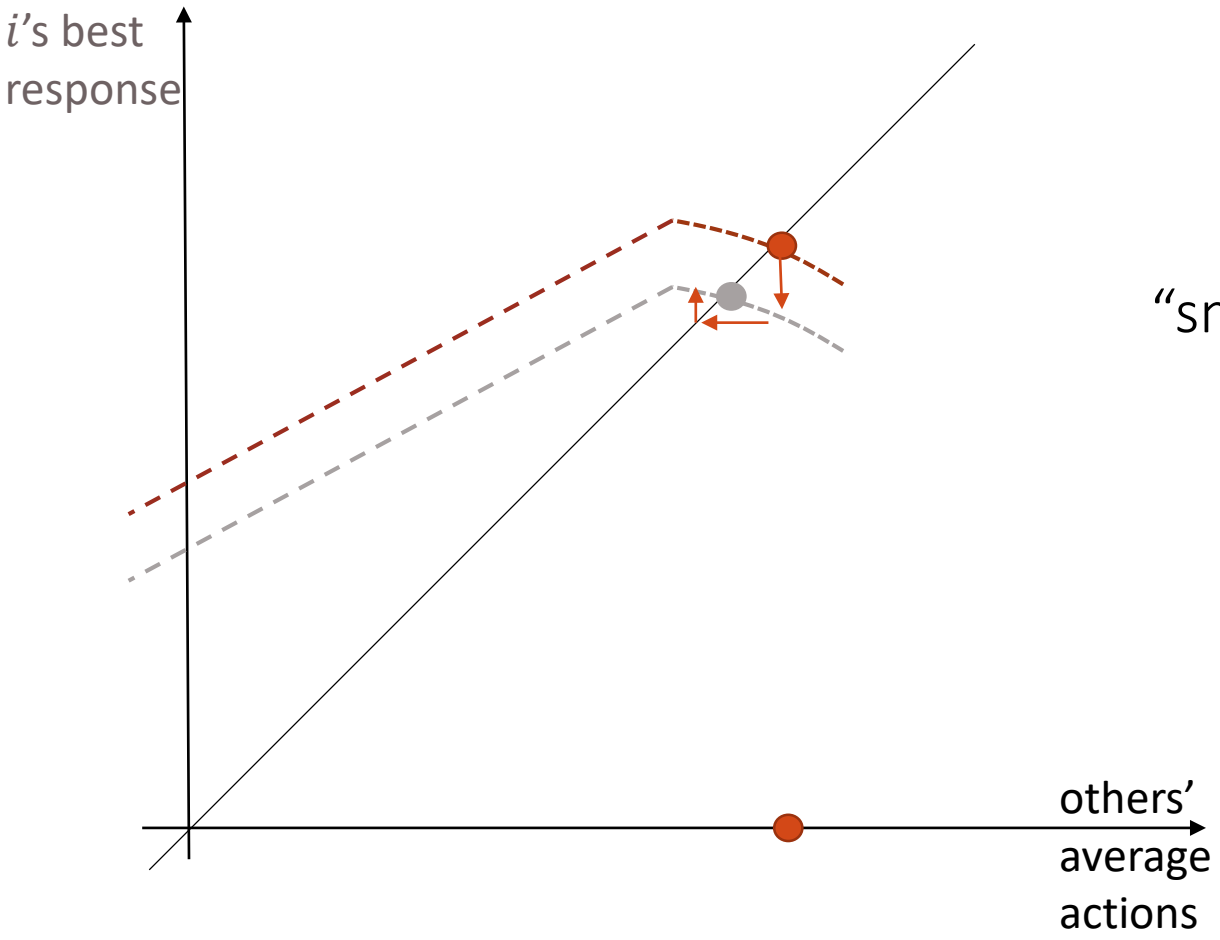
- After a large (fundamental) shock



"large shock amplifier"

Stabilizing after Small Shocks

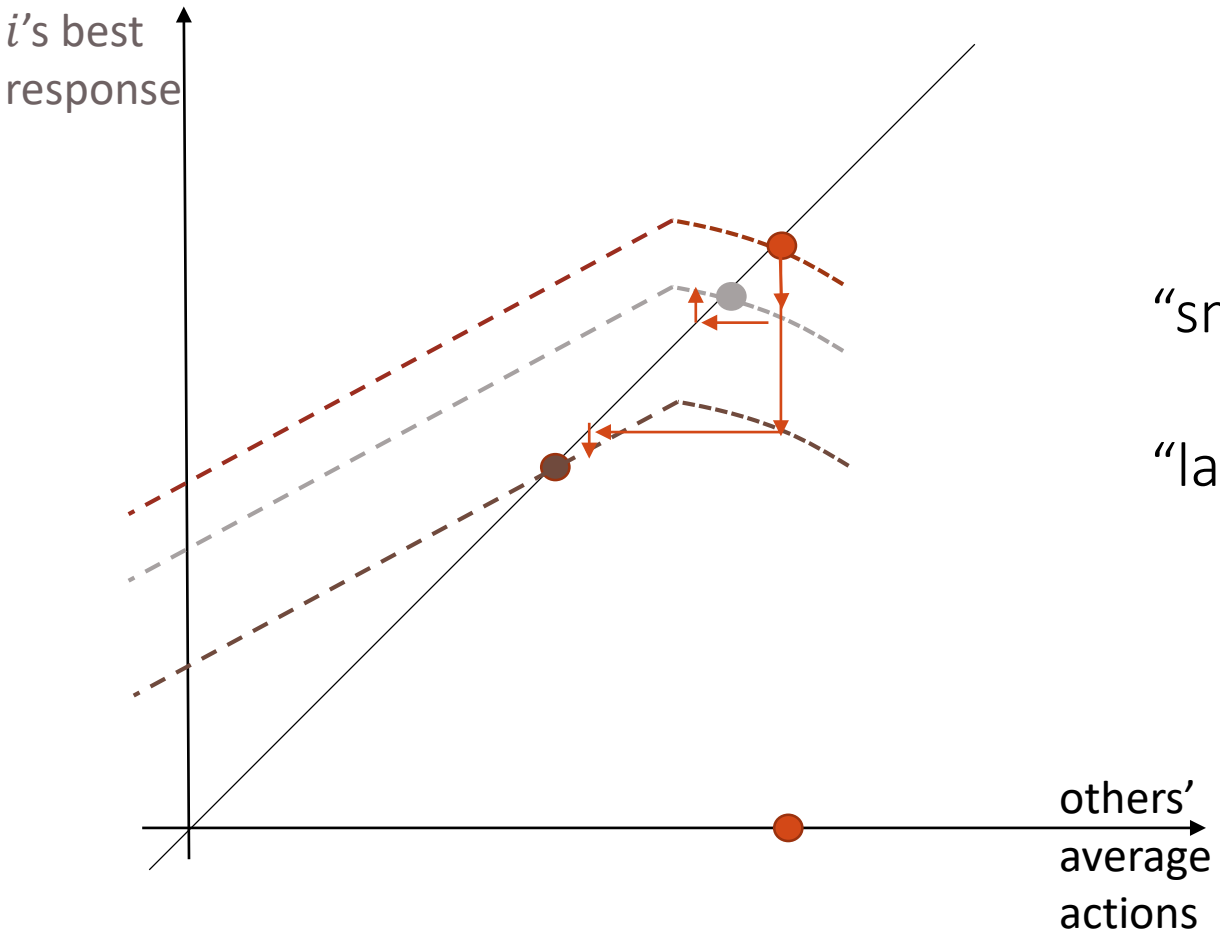
- After a small (fundamental shock)



"small shock absorber"

DeStabilizing after Large Shock

- After a large (fundamental) shock

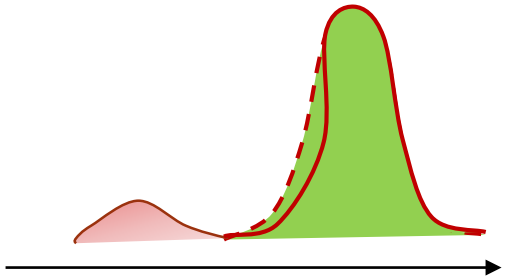


"small shock absorber"

"large shock amplifier"

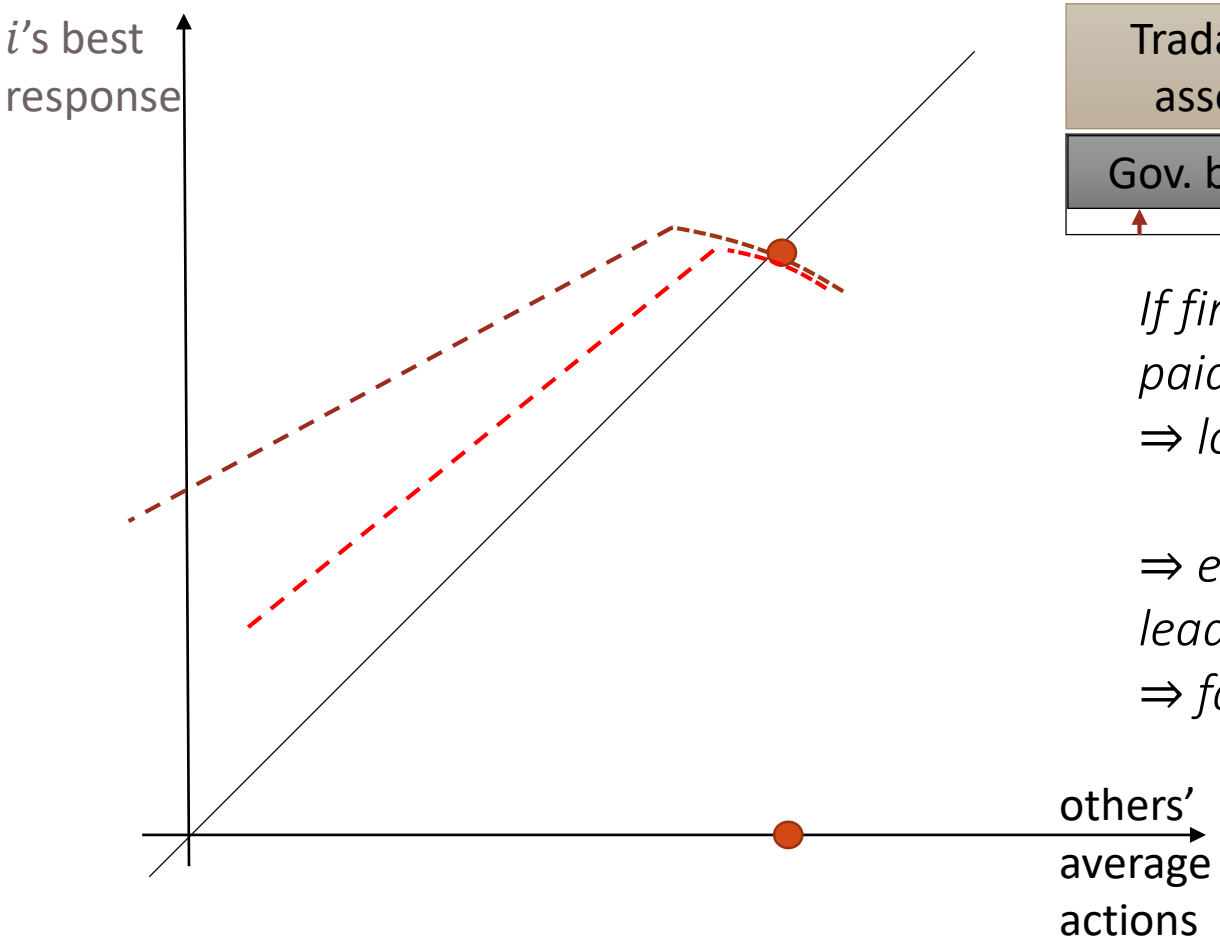
Crash 2: Endogenous Fat Tails

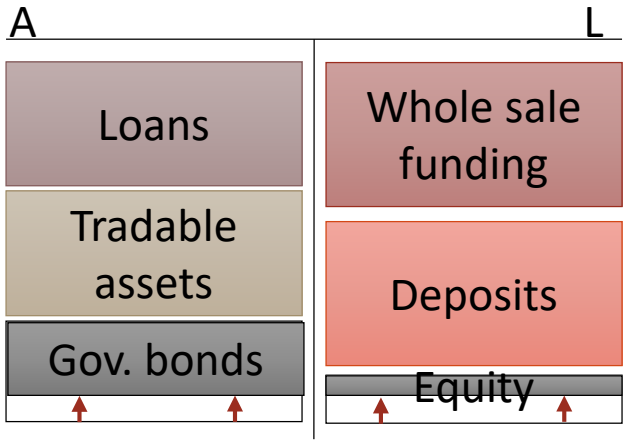
- Initial shock is normally distributed
- Return distribution due to strategic complementarities



Impact of Higher Leverage due to Stock Repurchase

- Starting point



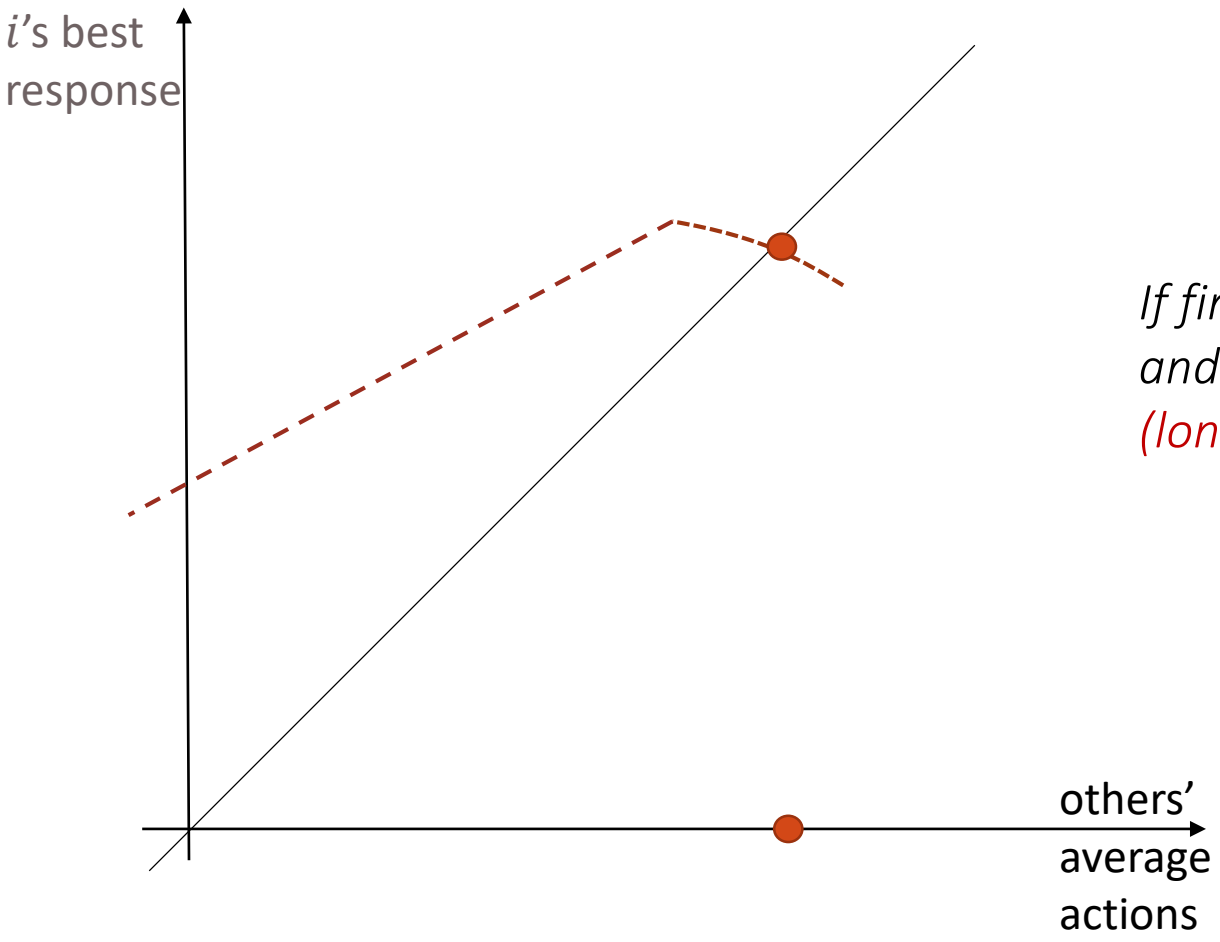


If firm repurchases equity paid with liquid asset
⇒ lower capital ratio

⇒ even smaller shocks lead to sharp drops
⇒ fat tails

Impact of More Liquidity Mismatch

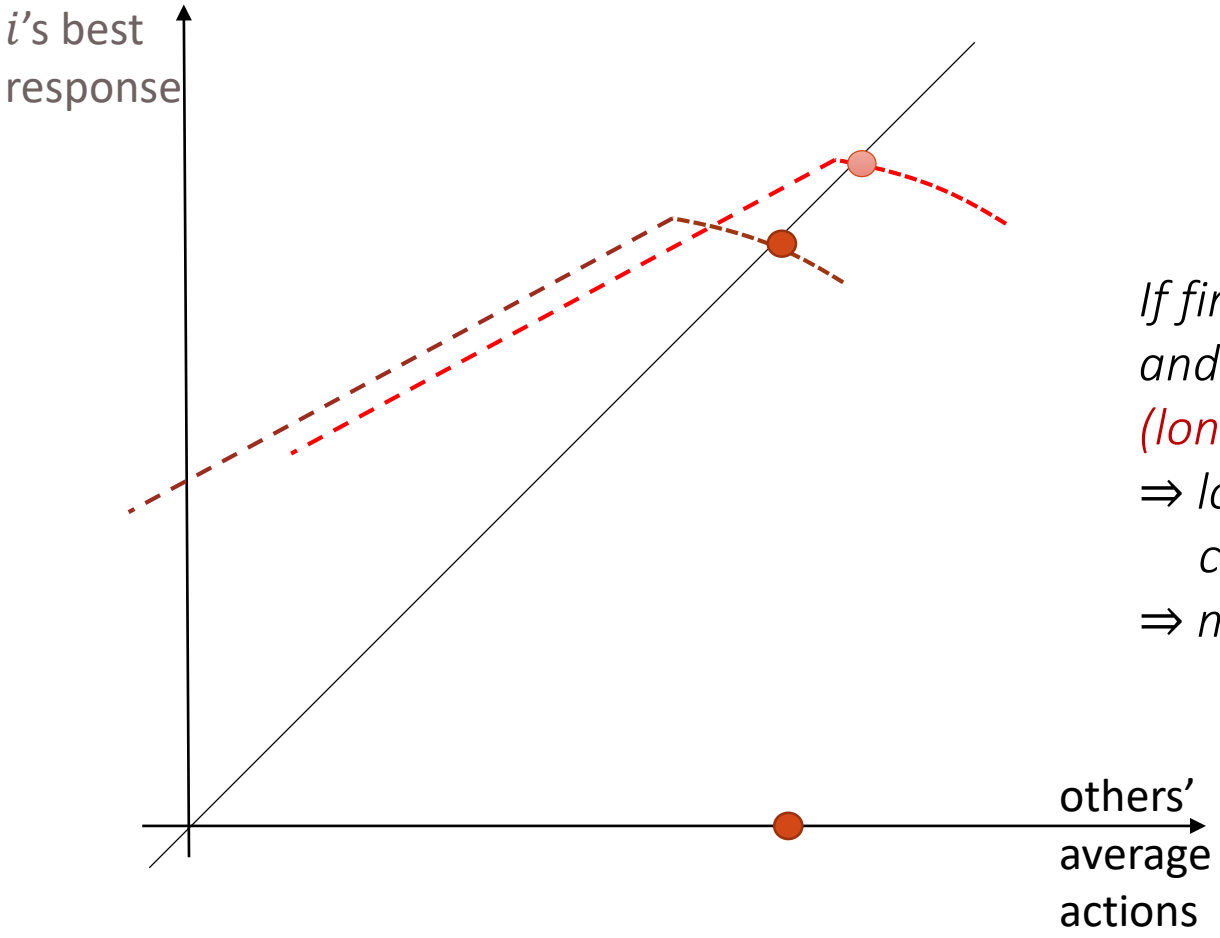
- Starting point



If firm sells liquid safe asset and buys less liquid risky (long-maturity) asset

Impact of More Liquidity Mismatch

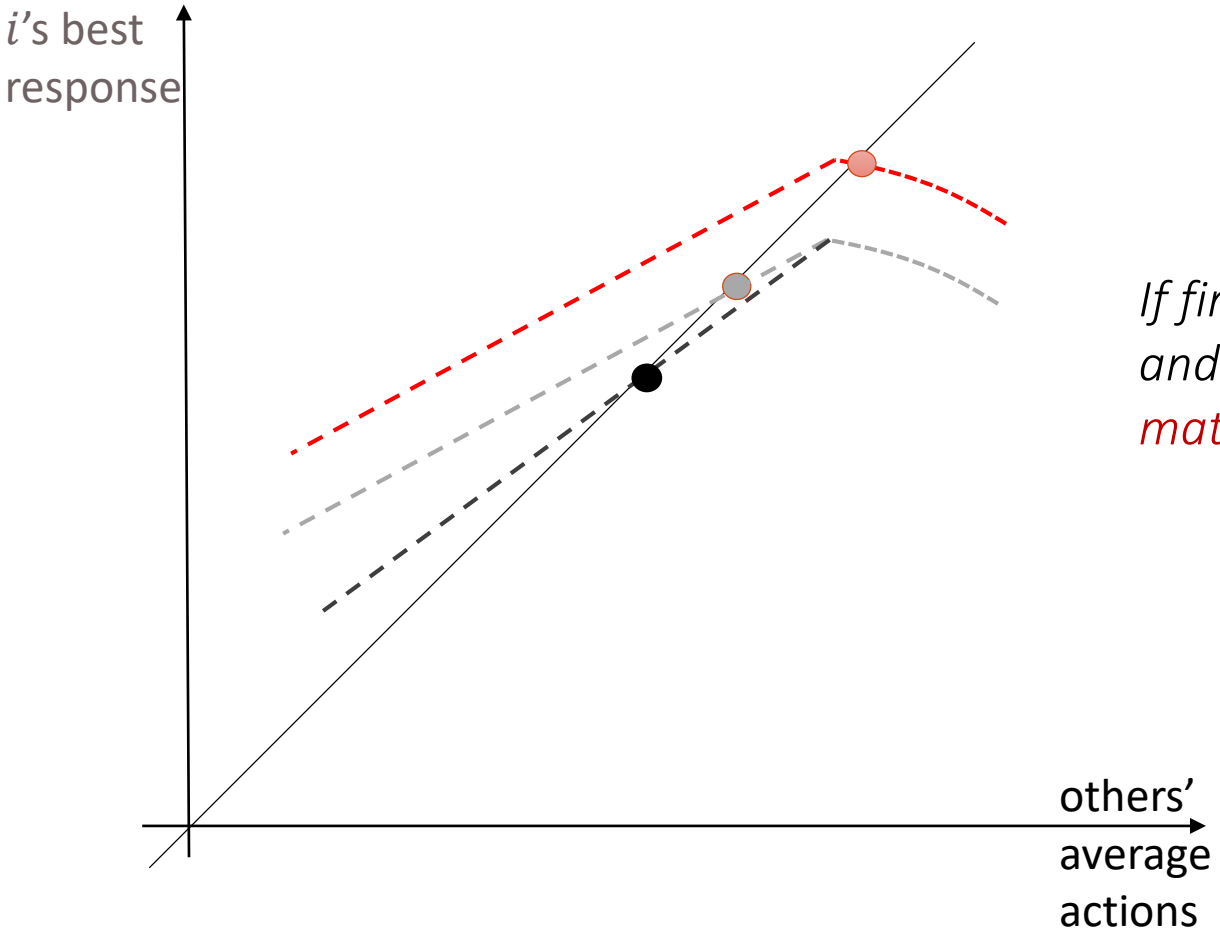
- Higher leverage



If firm sells liquid safe asset and buys less liquid risky (long-maturity) asset
⇒ *lower (risk-weigthed) capital ratio*
⇒ *more liquidity mismatch*

Impact of More Liquidity Mismatch

- Margin spiral ⇒ more strategic complementarity

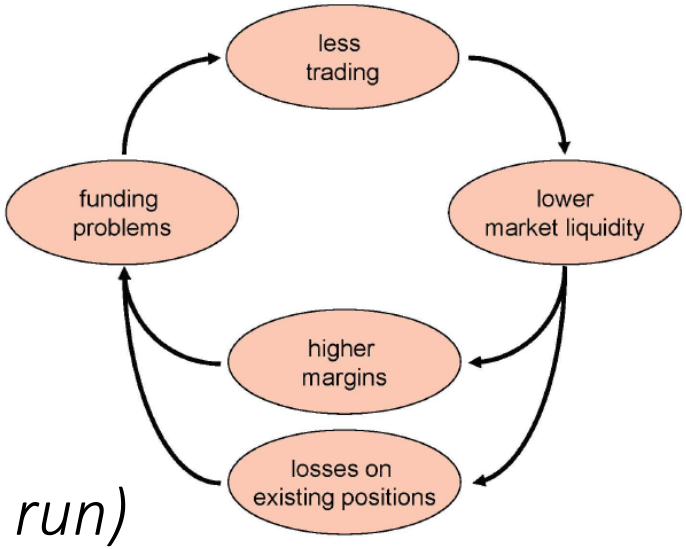


If firm sells liquid safe asset and buys less liquid (long-maturity) asset

Leverage Dynamics

- Credit cycle: *(Loss spiral)*
  - Constant volatility exog. shocks

  ⇒ Countercyclical leverage
  - Underinvestment (second best user problem)



- Leverage cycle: *(Margin spiral/Repo run)*
  - Exogenously time-varying volatility
    ARCH/Scary bad news ⇒ Destabilizing Margins

  ⇒ Pro-cyclical leverage

- Evidence: Pro- vs. countercyclical leverage depends on
  - investor type, book vs. market, new issuance vs. overall

Pro- vs. Counter-cyclical Leverage

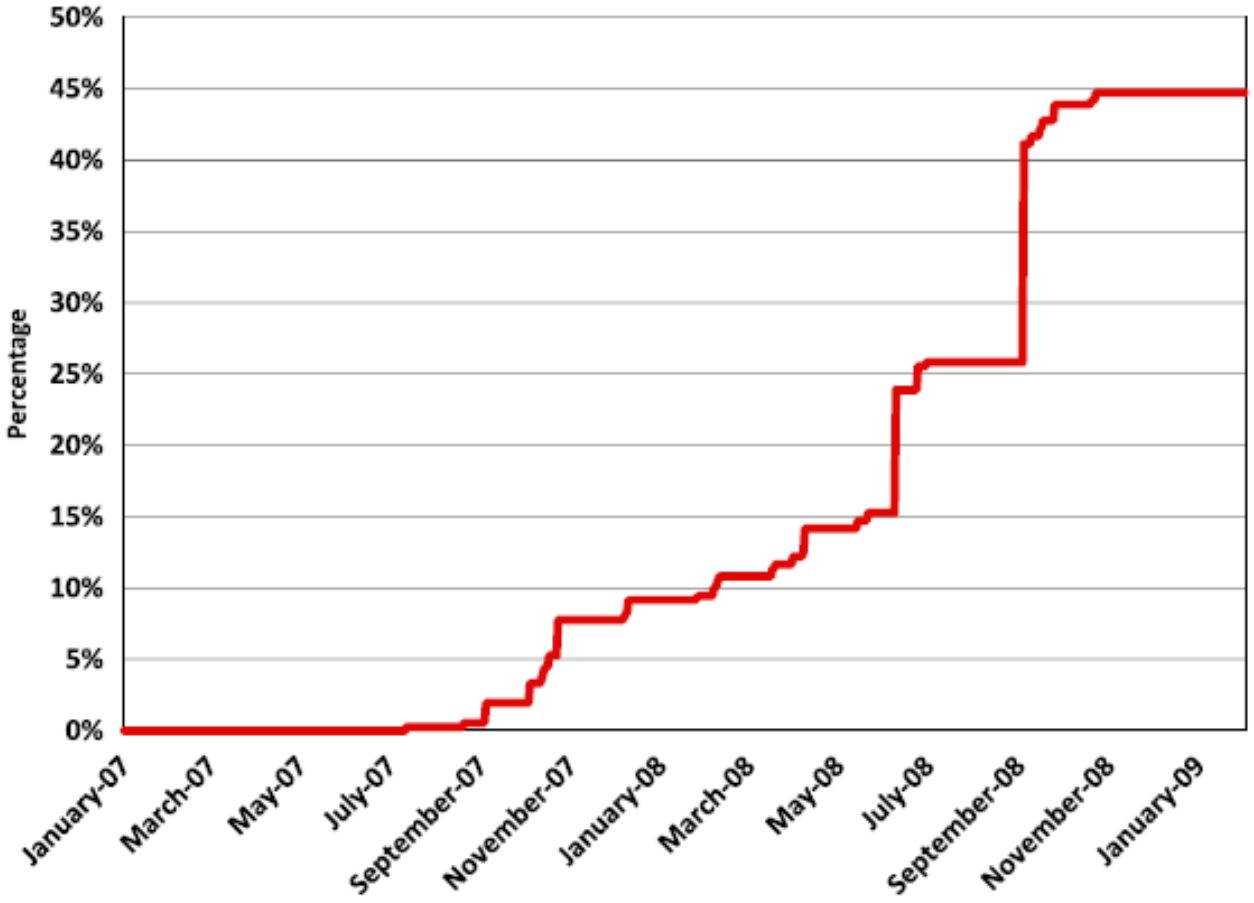
- Adrian-Shin (2014): Book vs. market leverage
  - Intermediaries finance new assets with debt ⇒ Procyclical
- Geanakoplos-Pedersen (2014): New vs. old leverage
  - Margins spike in crisis ⇒ Procyclical
- He, Kelly, Manela (2017): Different constraints
  - "Equity constraint": BGG/BruSan, countercyclical leverage
  - "Debt constraint": Leverage cycle, procyclical leverage
  - Book/market leverage positively correlated for dealers
  - Evidence from HFs in Ang et al. (2011)
    - HFs procyclical, investment banks countercyclical

Run on Repo or not?

1. Not system-wide
2. Tri-party and bilateral repo markets behaved very differently
3. In tri-party market, runs on
    a. select counterparties (Lehman)
        - Diamond-Dybvig run
    b. select collateral (private label MBS/ABS)
        - Brunnermeier-Pedersen run

Gorton & Metrick (2011)

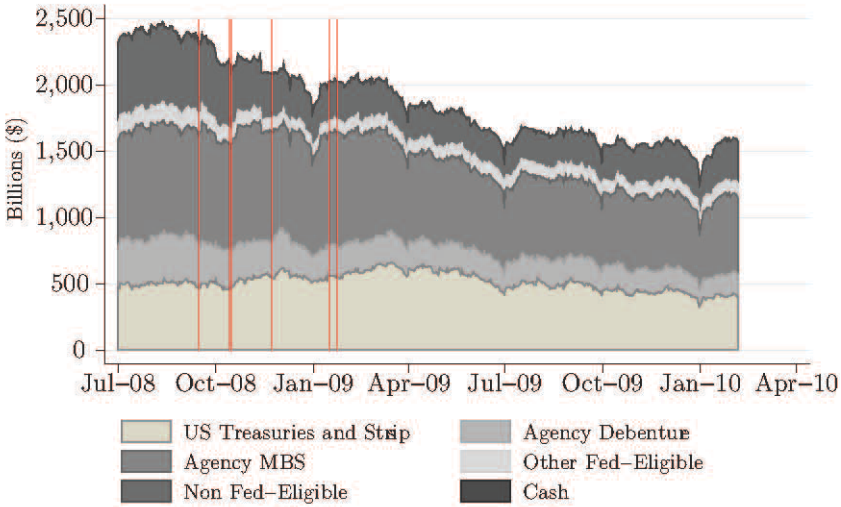
- Bilateral repo data (private date by Gorton)



US Repo Run? 2008/9

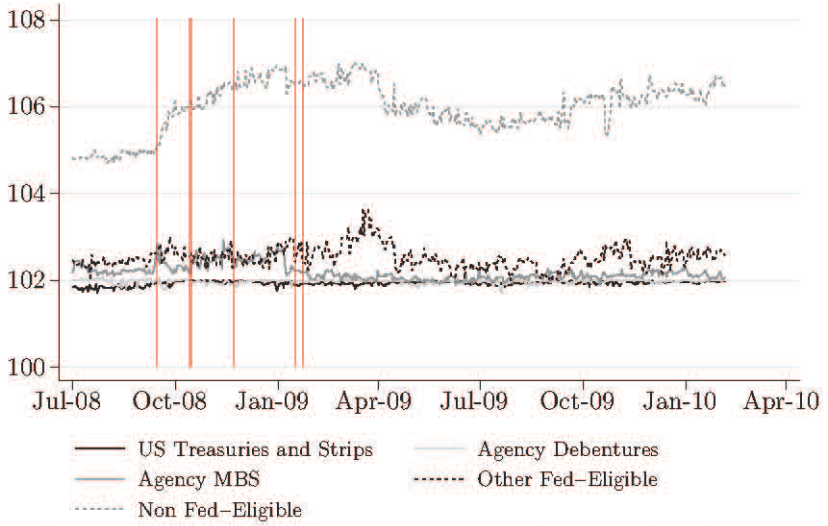
- Margins on collateral assets
  - **very stable** in tri-party repo market
    - Copeland, Martin, Walker (2011) http://www.ny.frb.org/research/staff_reports/sr477.pdf
    - Opposing view: Gorton, Metrick (2011)
  - Not stable on private MBS/ABS
    - but small relative to overall MBS/ABS market (3%)
    - ABCP was a much bigger part…
    - Krishnamurthy, Nagel, Orlov (2011
- Margin jump/run on selected counterparties
  - Bear Stearns (anecdotally)
  - Lehman (in data)
    - Not in Krishnamurthy et al.

Figure 6: Stacked Graph of Collateral



Note: July 17, 2008 excluded because no data was available for BNYM on that date. Red lines correspond to important market events. From left to right: 9/15/08 (Lehman), 10/14/08 (9 banks receive aid), 10/16/08 (UBS), 11/23/08 (Citi), 1/16/09 (B of A), 1/24/09 (Citi).

Figure 7: Median Haircuts by Asset Type



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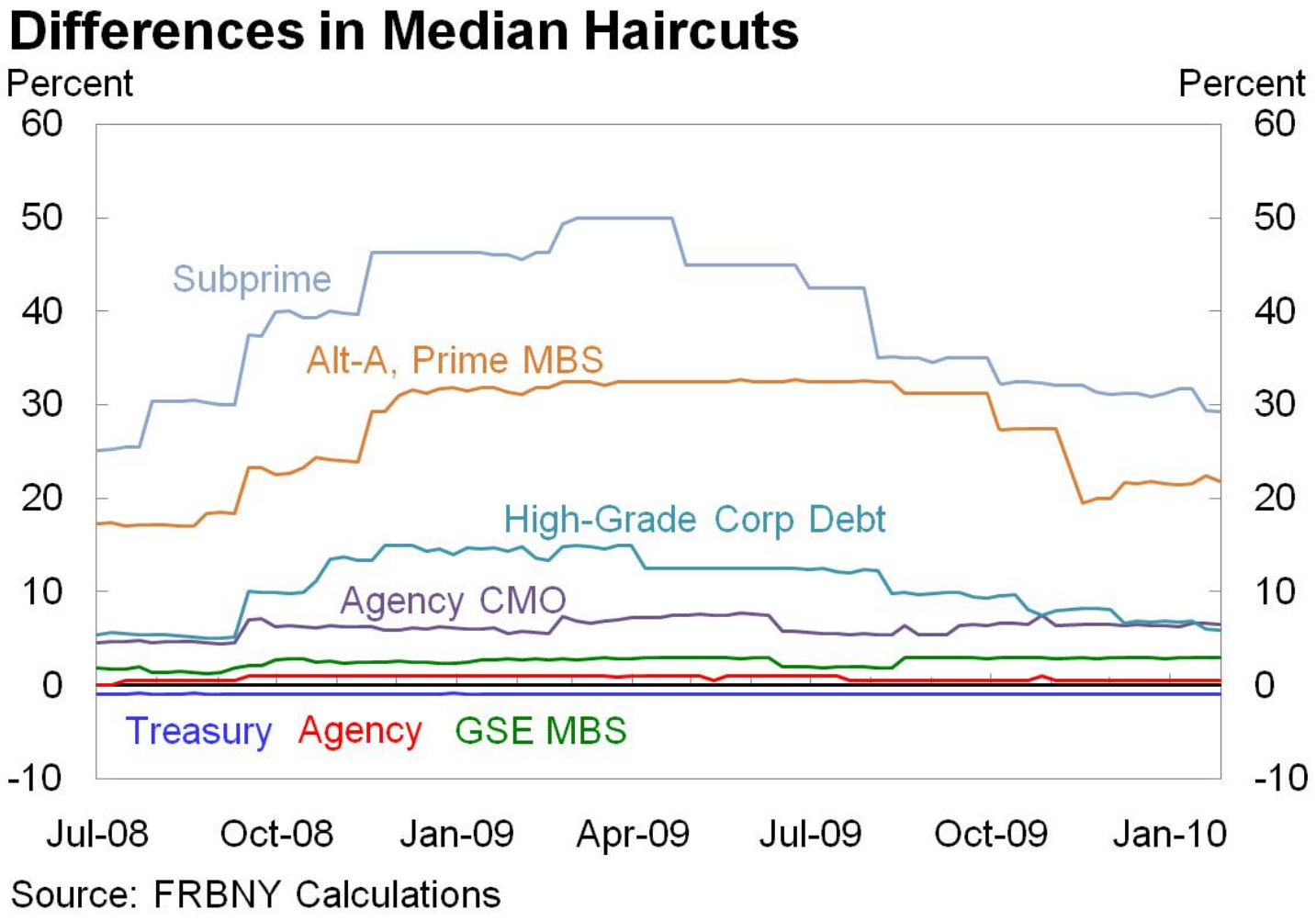
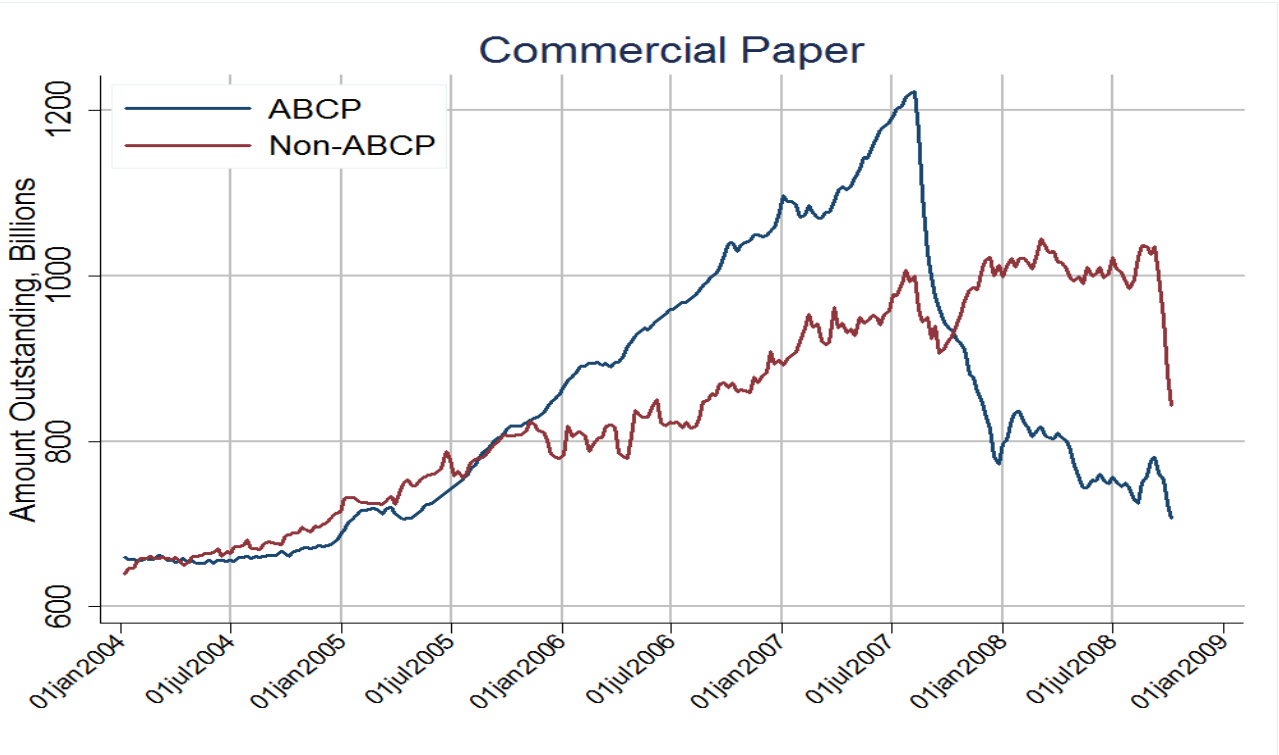
Bilateral and Tri-party Haircuts/Margins?

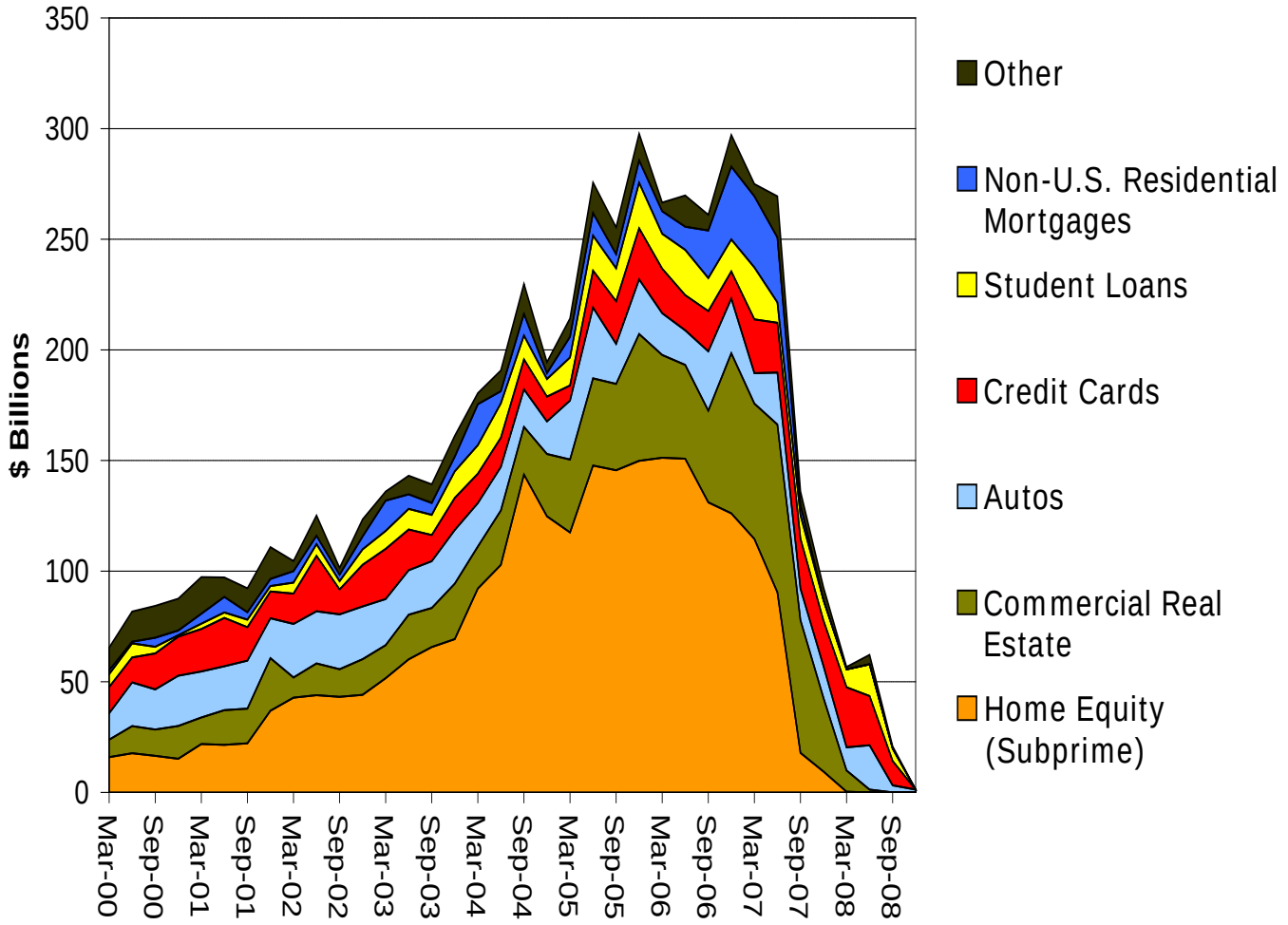


ABCP collapse – rollover risk

- ABCP dries up
  - no rollover, esp. by money market funds ("Break the Buck" Rule 2a-7)
- SIVs draw on credit lines of sponsoring bank
- Banking Crisis: IKB, SachsenLB, Northern Rock, IndyMac, …



ABCP: Composition



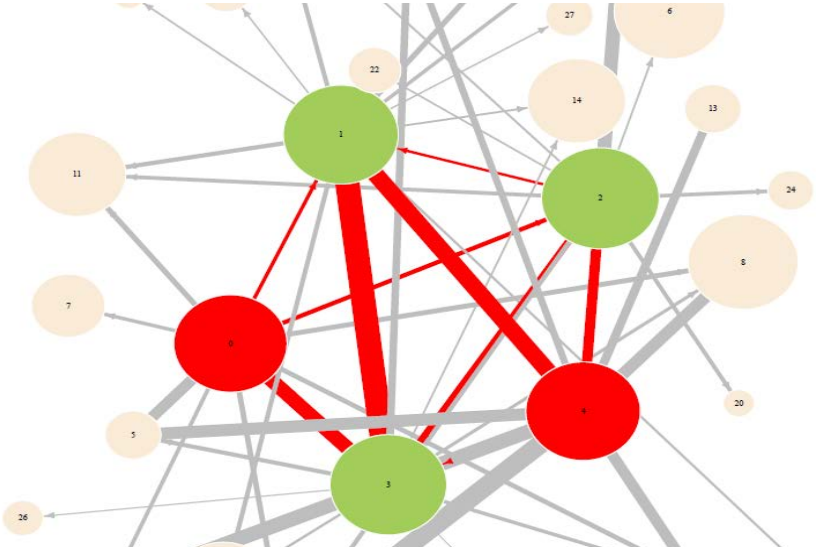
Crash 3: Spillover across Institutions

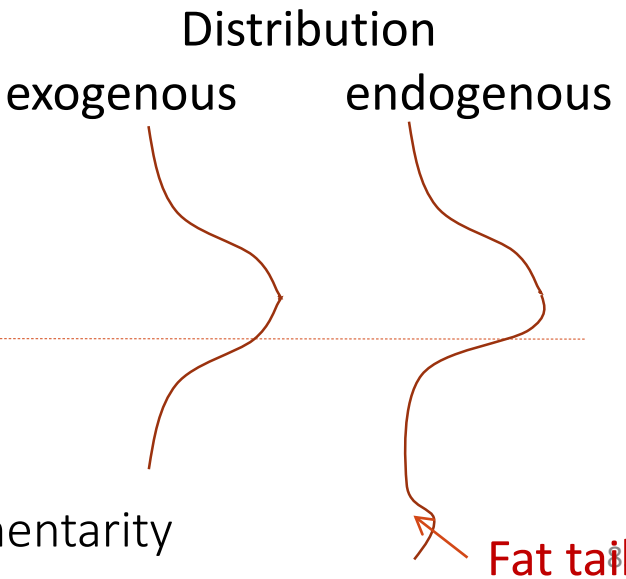
- Financial Contagion

- Broadly, two types:
  - Contractual linkages: (Direct) cross-exposures
  - General equilibrium linkages: (Indirect) price effects.

Absorbers vs. amplifier

Direct	Indirect
Contractual links	"Virtual links"
Loss through bankruptcy/default	Similar exposure than other levered players
Position data	**Response indicator** - expectations/ constraints



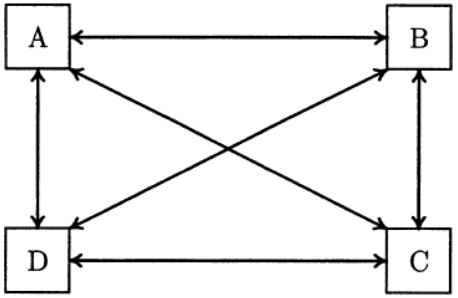


- Shock absorber
- Shock amplifier

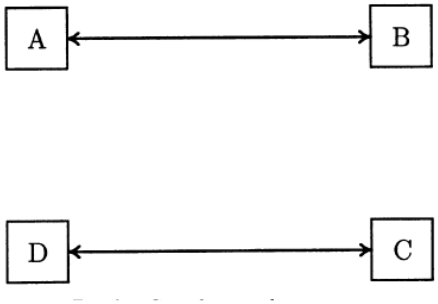
Depends on strategic substitutability/complementarity

Market Connectedness and Contagion

- Connected Interbank market



- Not fully connected market



- The more connected the larger is the scope for contagion
- Trade-off: Spillover/contagion vs. diversification!

Systemic Risk Measure: $\Delta CoVaR$

- *In returns*
- VaR_q^j is defined as quantile

$$\Pr\left(X^j \leq VaR_q^j\right) = q$$

- $CoVaR_q^{j|C(X^i)}$ is the conditional quantile

$$\Pr\left(X^j \leq CoVaR_q^{j|C(X^i)} | C(X^i)\right) = q$$

- The contribution

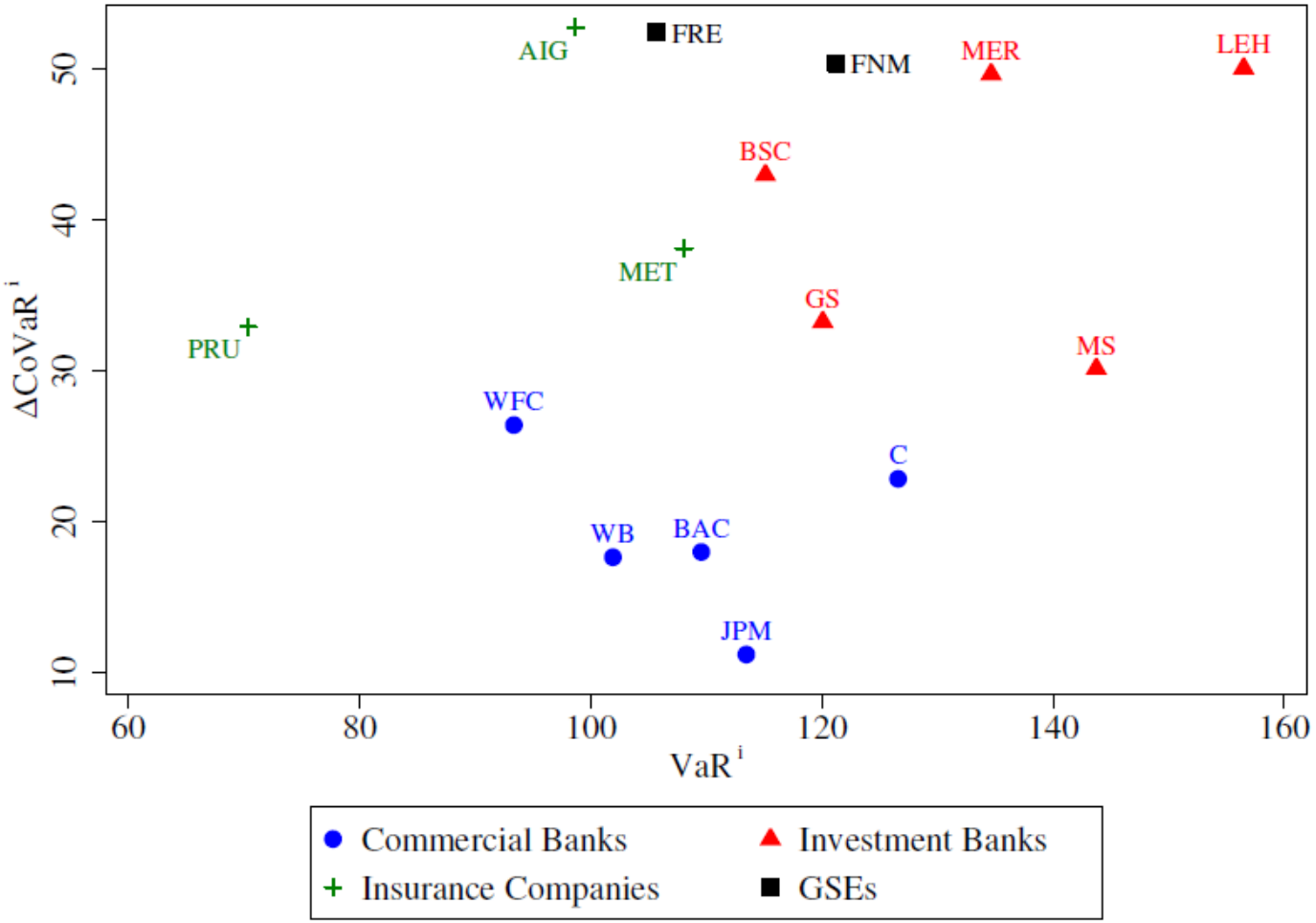
$$\Delta CoVaR_q^{j|i} = CoVaR_q^{j|X^i=VaR_q^i} - CoVaR^{j|X^i=VaR_{50}^i}$$

- *In dollars*

$$\Delta^{\$} CoVaR_q^{j|i} = \text{Size}^{\text{i}} * \Delta CoVaR_q^{j|i}$$

$\Delta CoVaR$ vs. VaR

- Probability of a tree catching fire
- Probability of a tree on fire spilling over to forest



Various conditionings

- $\Delta CoVaR$
  - Q1: Which institutions move system (in a non-causal sense)
  - VaR^{system} | institution i in distress
- Exposure $\Delta CoVaR$
  - Q2: Which institutions are most exposed if there is a systemic crisis?
  - VaR^{i} | system in distress
- Network $\Delta CoVaR$
  - VaR of institution j conditional on i
- Asset by asset $\Delta CoVaR$

in non-causal sense!

Crash 3: Paradox of Prudence

- "Micro-prudence" of bank is "macro-imprudent"
- Two "spirals" amplify
  - Liquidity spiral (price of capital)
  - Disinflationary spiral (price of money)

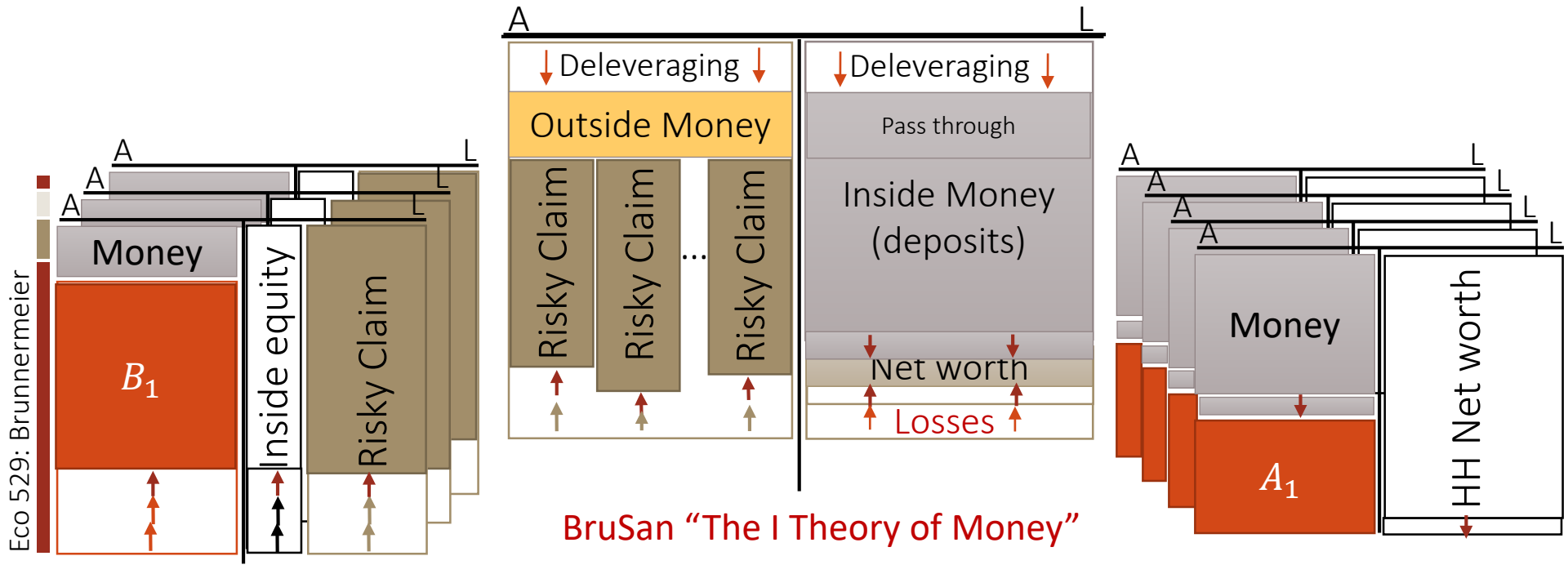
Like Keynes' Paradox of Thrift, but in risk-space

Crash 3: Paradox of Prudence

- "Micro-prudence" of bank is "macro-imprudent"
- Two "spirals" amplify
  - Liquidity spiral (price of capital)
  - Disinflationary spiral (price of money)
    - Banks issue less inside money (& diversify less risk risk)
    - HH demand more money

⇒Lower inflation

Like Keynes' Paradox of Thrift, but in risk-space



BruSan "The I Theory of Money"

Crash 4: Spillovers Across Assets

- Net worth channel:
  - Expert net worth affects all assets
    BGG/KM/BruSan/Diamond-Rajan (2005)
  - Leverage cycle: Spillovers from "crossover" investors JG
    - Margins spike in one market

    ⇒ Crossover investors transfer capital from other markets
  - BruPed: Multiple equilibria:
    Joint jump in price across assets
    - Even assets with uncorrelated payoffs jump together
    - Could also be integrated in a DD-model

- Measurement: *CoVaR*

Overview: Financial Crises

- Run-up phase
  - Distorted Beliefs
  - Concentration of Risk
  - Maturity Shortening
- Crash phase
  - Traditional Bank Runs
  - Modern Banks and Liquidity Spirals
  - Fire-sales
  - Spillovers
- Recovery phase
  - Persistence vs. Resilience
  - Dynamic Amplification
  - Volatility Dynamics/Volatility Paradox

Persistence

- Even in standard real business cycle models, temporary adverse shocks can have long-lasting effects
- Due to feedback effects, persistence is much stronger in models with *financial frictions*
  - Bernanke & Gertler (1989)
  - Carlstrom & Fuerst (1997)
- Negative shocks to net worth exacerbate frictions and lead to lower capital, investment and net worth in future periods

CF: Persistence & Dampening

- Negative shock in period t decreases N_t
  - This increases financial friction and decreases I_t
- Decrease in capital supply leads to
  - Lower capital: K_{t+1}
  - Lower output: Y_{t+1}
  - Lower net worth: N_{t+1}
  - Feedback effects in future periods $t + 2, \ldots$
- Decrease in capital supply also leads to
  - Increased price of capital q_t
  - Dampening effect on propagation of net worth shock

Persistence ⇒Dynamic Amplification

- Bernanke, Gertler and Gilchrist (1999) introduce *technological illiquidity* in the form of nonlinear adjustment costs to capital
- Negative shock in period t decreases N_t
  - This increases financial friction and decreases I_t
- In contrast to the dampening mechanism present in CF, now decrease in capital demand (not supply) leads to
  - Decreased price of capital due to adjustment costs
  - *Amplification* effect on propagation of net worth shock

Bernanke, Gertler & Gilchrist (BGG)

- BGG assume separate investment sector
  - This separates entrepreneurs' capital decisions from adjustment costs
- $\Phi(\cdot)$ represents *technological illiquidity*
  - Increasing and concave with $\Phi(0) = 0$
  - $K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right) K_t + (1 - \delta) K_t$
- FOC of investment sector
  - $\max_{I_t} \{q_t K_{t+1} - I_t\} \Rightarrow q_t = 1/\Phi'\left(\frac{I_t}{K_t}\right)$

Kiyotaki & Moore (KM) '97

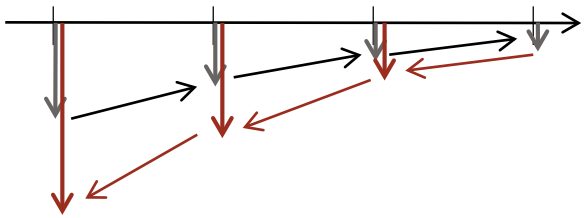
- Kiyotaki, Moore (1997) adopt a
  - collateral constraint, $Rb_t \leq q_{t+1}k_t,$ instead of CSV
  - *market illiquidity* – second best use of capital
- Output is produced in two sectors, differ in productivity
- Aggregate capital is fixed, resulting in
  - extreme *technological illiquidity*
  - Investment is completely irreversible
- Durable asset has two roles:
  - Collateral for borrowing
  - Input for production

KM Amplification

- *Static* amplification occurs because fire-sales of capital from productive sector to less productive sector depress asset prices
  - Importance of *market liquidity* of physical capital
- *Dynamic* amplification occurs because a temporary shock translates into a persistent decline in output and asset prices
  - Forward
  - Backward

grow networth via retained earnings

asset pricing



"Kocherlakota Critique"

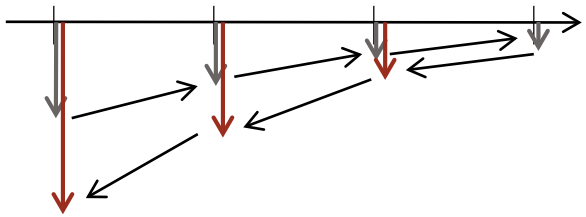
- Amplification for negative shocks differs from positive shocks
  - In Kocherlakota (2000) optimal scale of production (positive shock does not lead to expansion)
- Amplification is quantitatively too small
  - Capital share is only 1/3 and hence GDP is too small
  - Cordoba and Ripoll (2004)
    - Needs sizeable capital share plus
    - Low intertemporal substitution

"Single Shock Critique"

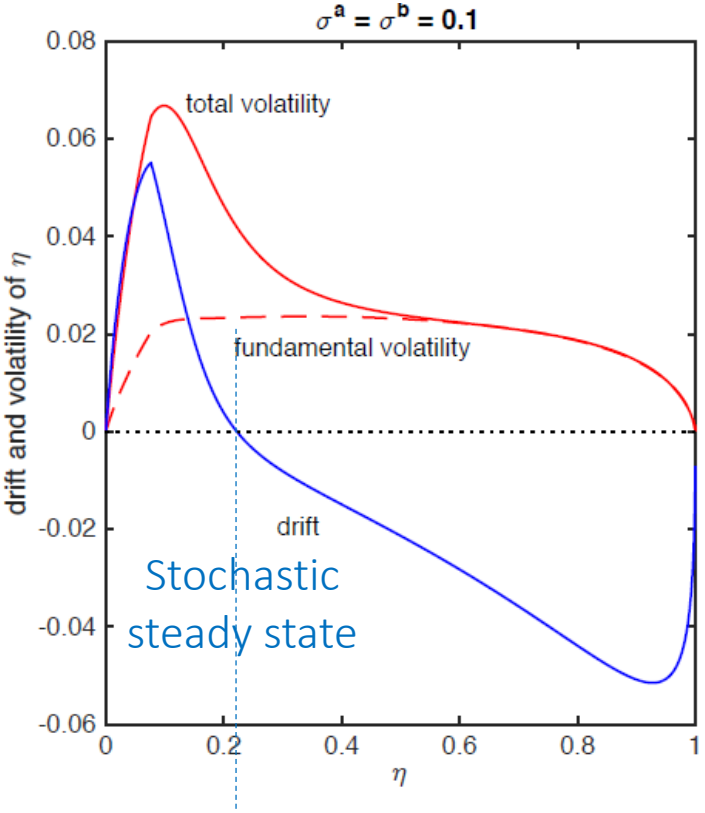
- Critique: After the shock all agents in the economy know that the economy will deterministically return to the steady state.
  - Length of slump is deterministic (and commonly known)
    - No safety cushion needed
  - In reality an adverse shock may be followed by additional adverse shocks
    - Build-up extra safety cushion for an additional shock in a crisis
- Impulse response vs. volatility dynamics

Endogenous Volatility & Volatility Paradox

- Endogenous Risk/Volatility Dynamics in BruSan
  - Beyond Impulse responses



  - Input: constant volatility
  - Output: endogenous risk
    time-varying volatility



⇒Precautionary savings
  - Role for money/safe asset

⇒ Nonlinearities in crisis ⇒ endogenous fait tails, skewness

- Volatility Paradox
  - Low exogenous (measured) volatility leads to high build-up of (hidden) endogenous volatility (Minksy)

Conclusion

- "Run-up", "Crisis", and"Recovery"-mechanisms
  - Belief-focused (representative + heterogeneous)
  - Friction-focused, where risk is central
- Risk concentration, fire-sales, spillovers, …
- Paradox of Prudence
- Volatility Paradox
  - Mean-Amplification, Exog. ARCH, Endog. Volatility Dynamics

- Macro/Monetary models with financial sector should include
  - physical investment
  - inside money creation

Extra Slides