# Market and funding Liquidity CoVaR

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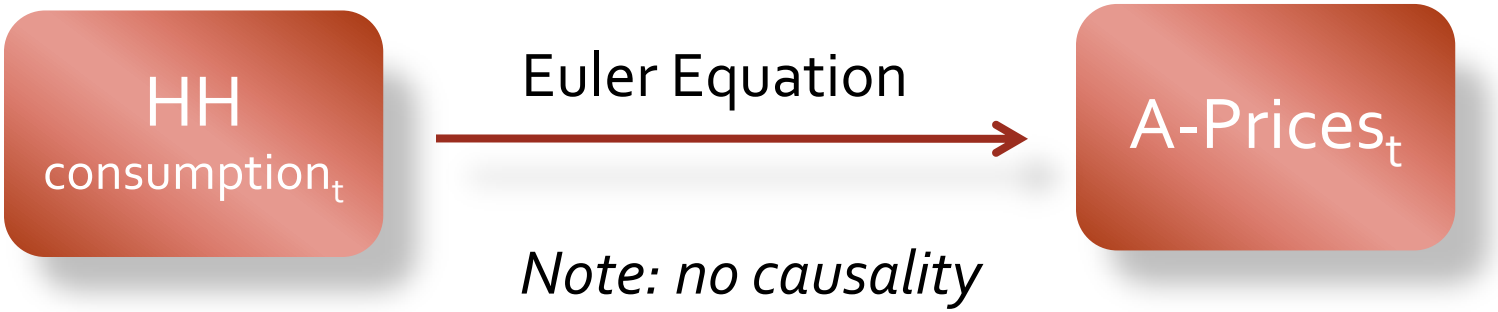
# Represent. Agent "Euler Equation Finance"

- No (funding) friction ⇒ Financial sector is a veil
  - Starting with Lucas …
  - Perfect aggregation

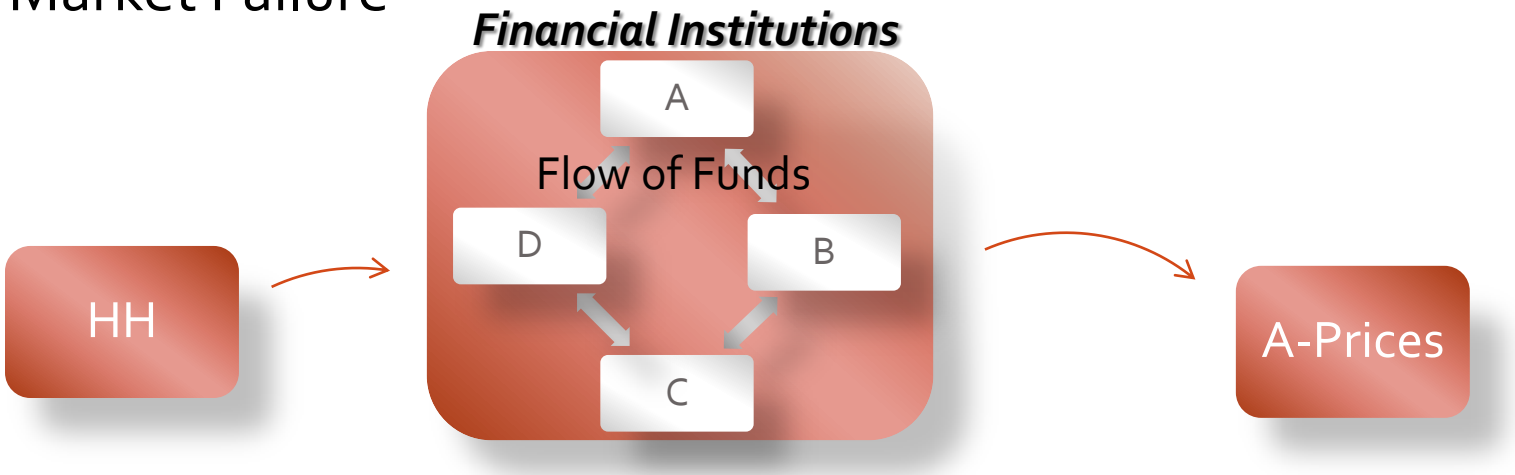



⇒ Pricing kernel = MRS of representative household

- Modeling: exotic preferences/utility functions + beliefs
- Data source: Consumption

# "Institutional Finance"

- Funding frictions are at the center
  investors with expertise rely on funding w/o expertise
  - No aggregation
  - Market Failure




→ Pricing Kernel = Shadow cost of funding (liquidity)

- Modeling: institutional frictions
- Data source: Flow of funds

# Funding Liquidity Constraints – Margins/haircuts determine Leverage

- Finance a long position $x^+>0$ at price $p_t=100$
  - Borrow \$90 per share
  - Margin $m^+=\$10$
- Finance a short position $x^->0$
  - Borrow security, lend collateral of \$110
  - Short-sell security at \$100
  - Margin/haircut = \$10
- Funding (liquidity) constraint

$$\sum_j x_t^{j+} m_t^{j+} + x_t^{j-} m_t^{j-} \le W_t$$

- With cross-margining

$$M_t(x_t^1,\ldots,x_t^J) \le W_t$$

# Funding Constraint is everywhere

- Exchanged traded products
- Repos
- …
- Regulatory
  - Banks: Basel accord
    - Basel I
    - Basel II: Value at Risk approach
  - Brokers/Investment banks: SEC's net capital rule
    - Internal risk models: Cross-margining from Aug 2004
  - Individual investors: Reg T

# Three Flavors of Funding Liquidity

- Margin funding risk *Prime broker*
  - Margin has to be covered by HF's own capital
  - Margins increase at times of crisis
- Rollover risk *ABCP*
  - Inability to roll over short-term commercial paper
- Redemption risk *Depositors, HF-investors*
  - Outflow of funds for HFs and banks

Essentially the same!

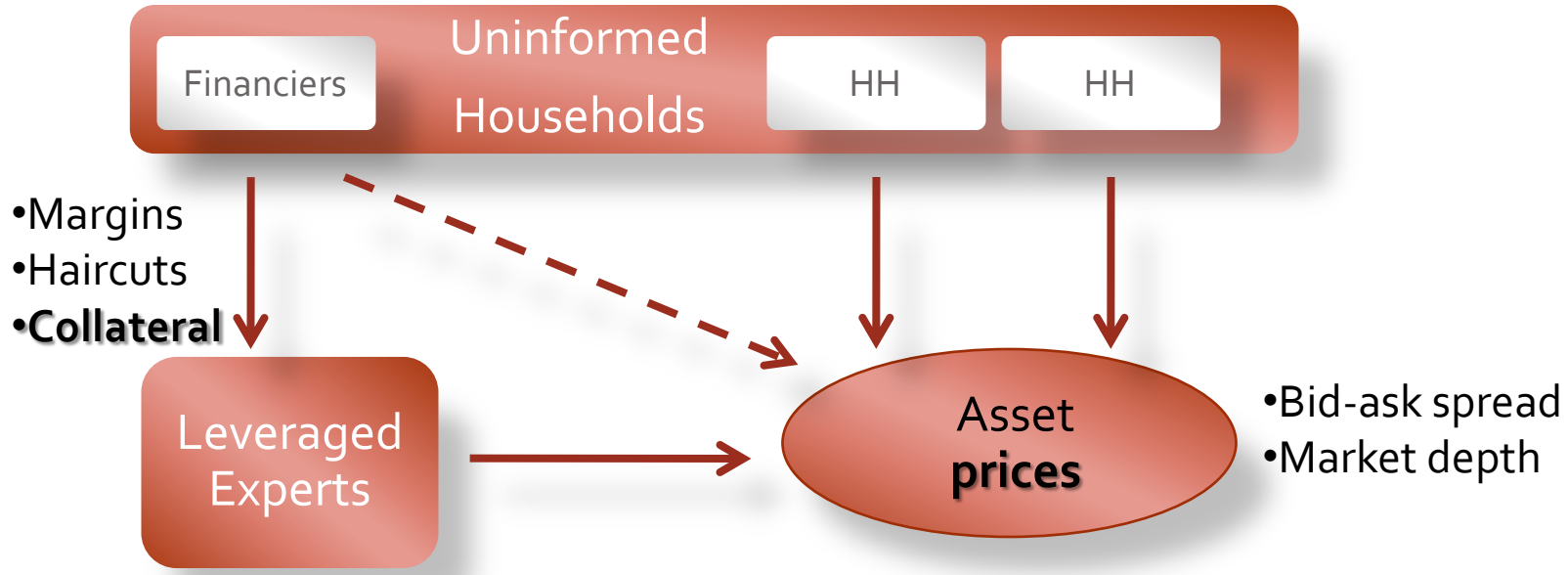
Maturity mismatch:

Long-term assets (with low market liquidity)
Short-term borrowing

# Overview

- Fragility
- Liquidity spirals
  - Loss spiral
  - Margin/haircut spiral ⇒ delevering ⇒ *Procyclicality*
- Fire sale externality
- Implications for financial regulation
  - Focus on *externalities* – measure CoVaR
  - Countercyclical regulation
  - Incorporate funding side

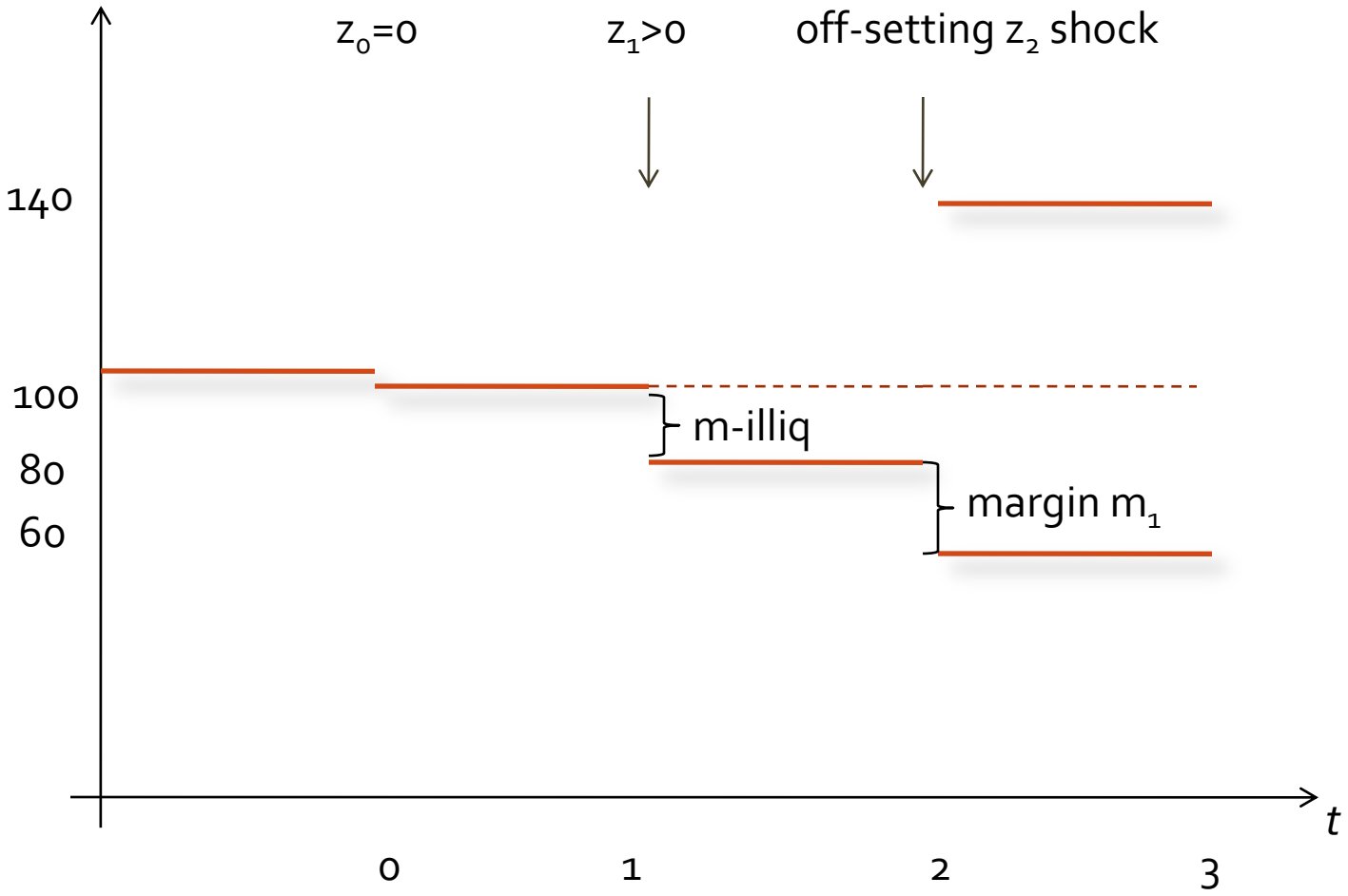
# Funding and Market Liquidity (with Lasse Pedersen)




- **Funding Liquidity**
  - Ease … raise funds by using asset as collateral
  - $m^+ x^+ + m^- x^- \leq W$
  - Lagrange multiplier
  - Margins/haircuts can be changed every day
    - Short-term lending

- **Market Liquidity**
  - Ease with which one can raise funds by selling asset
  - Asset price
    - pricing kernel

# Model setup – (simplified)



# Model setup II

- Volatility is time-varying – ARCH process

$$v_t^j = v_{t-1}^j + \Delta v_t^j = v_{t-1} + \sigma_t^j \varepsilon_t^j, \text{ where } \varepsilon_t^j \sim^{iid} \mathcal{N}(0,1)$$

$$\sigma_{t+1}^j = \underline{\sigma}^j + \theta |\Delta v_t^j|$$

- Speculators
  - Risk neutral, but capital constrained
  - Hold "leveraged" position financed by financiers
  - Go to their limit at t=1, i.e. $x^+ = W/m$
- Financiers are uninformed
  cannot distinguish between price drop due to
  - Temporary liquidity shock
  - Permanent fundamental shock

# Model setup: Financiers margin setting

- Margin = f(Value-at-Risk)
- A price drop leads to higher margins
- Intuition:
  - Price drop is likely due to fundamental shock
  - Large fundamental shock leads to higher future volatility (ARCH process)
  - Value at risk measure shoots up ⇨ margins increase
- Alternative mechanisms
  1. VaR is calculated based on past data (great moderation = great complacency)
  2. Adverse selection increases (Bernanke-Gertler)

cashflow

debt becomes more info-sensitive

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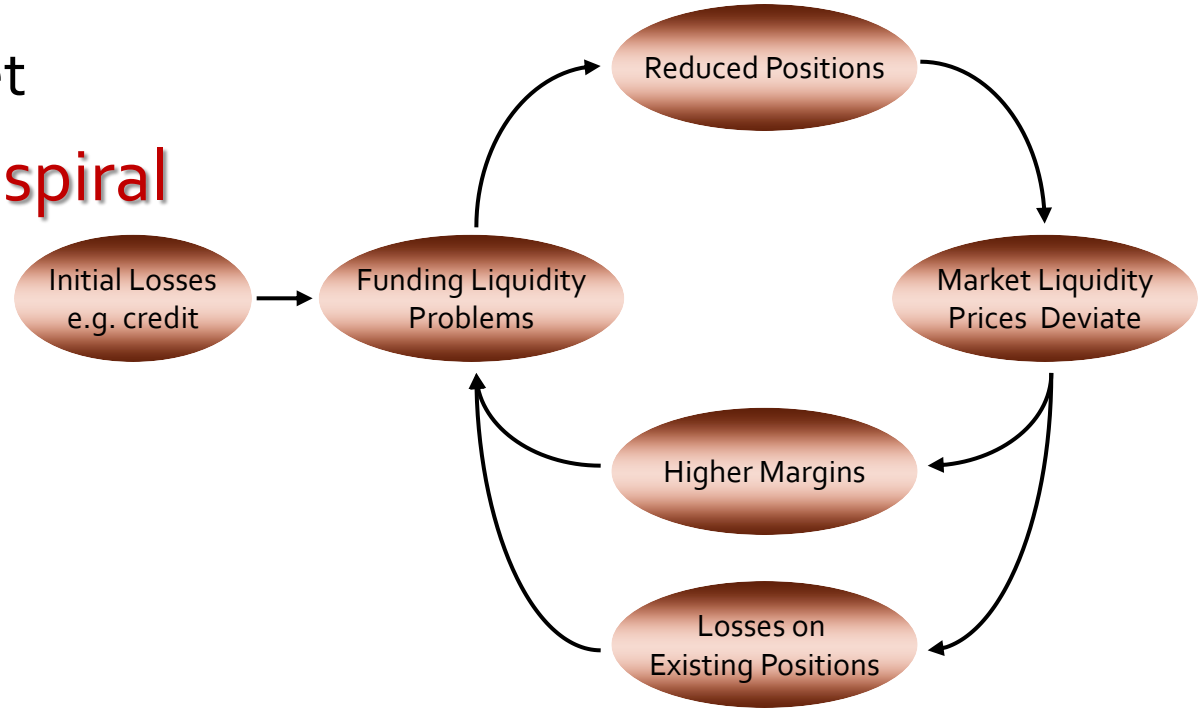
# Liquidity spirals

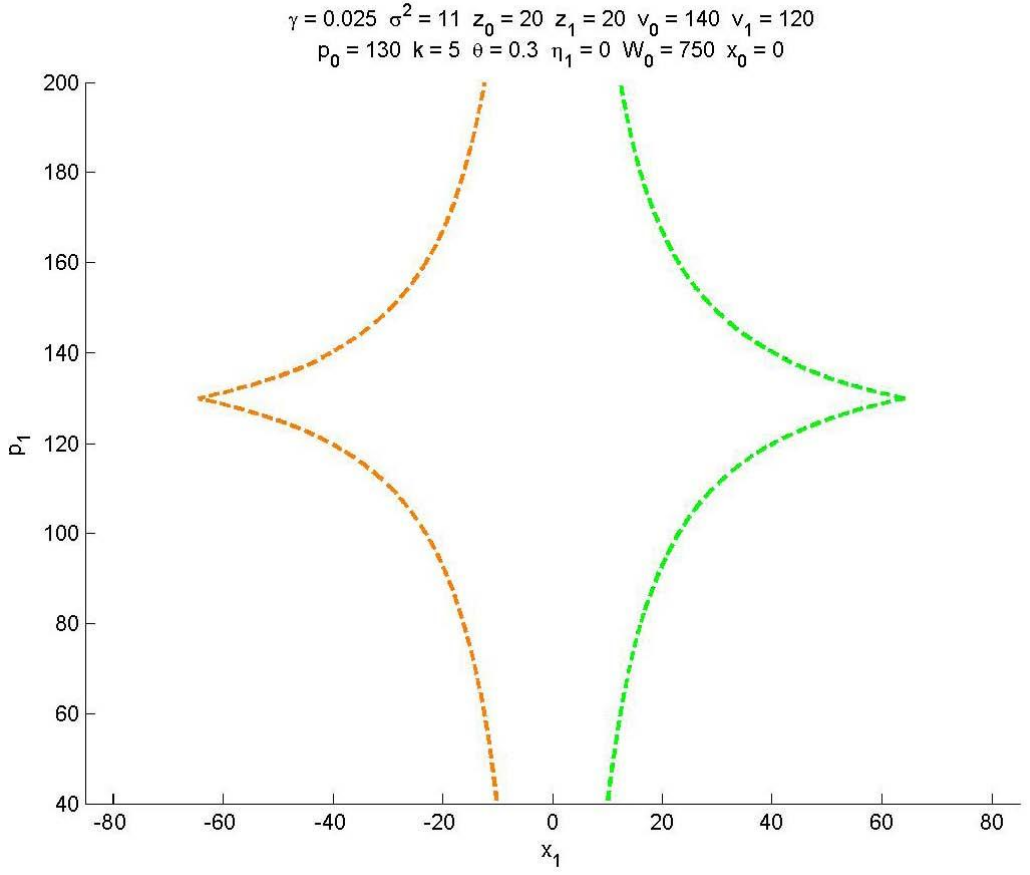
- **Loss spiral**
  - same leverage
    - mark-to-market
- **Margin/haircut spiral**
  - delever!
    - mark-to-model



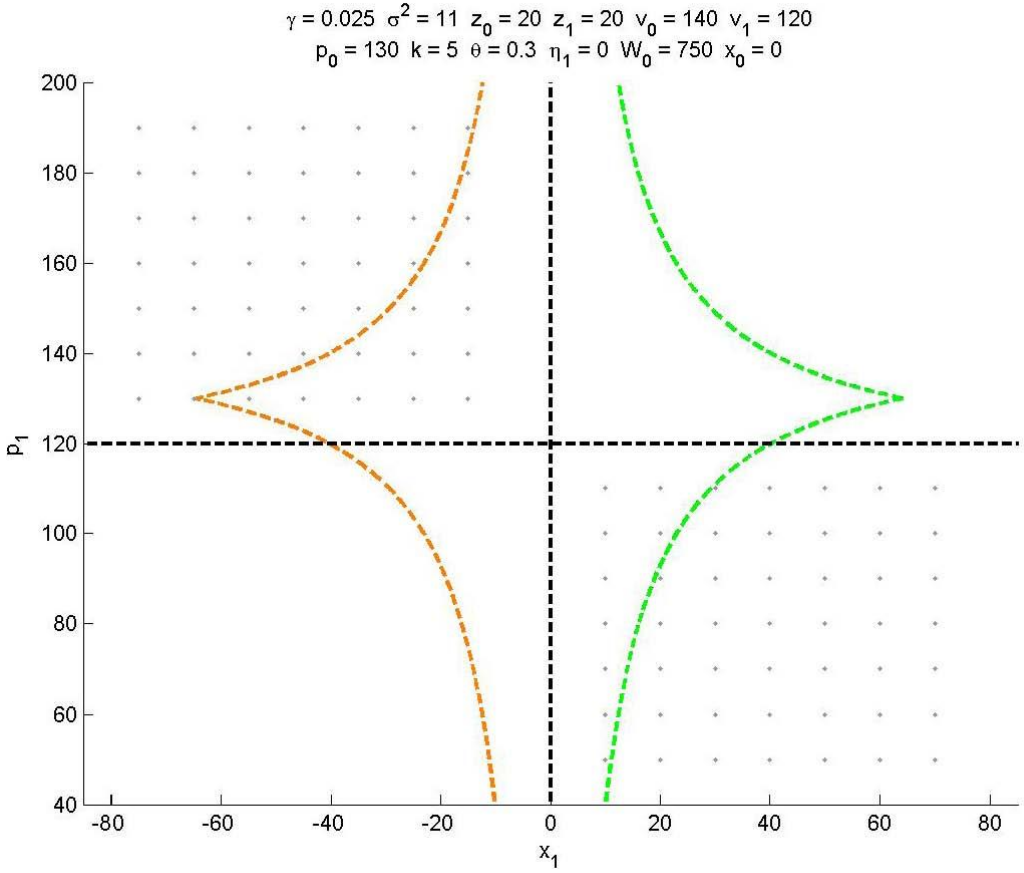

Brunnermeier-Pedersen (2009)

# In more detail … Speculators demand at t=1

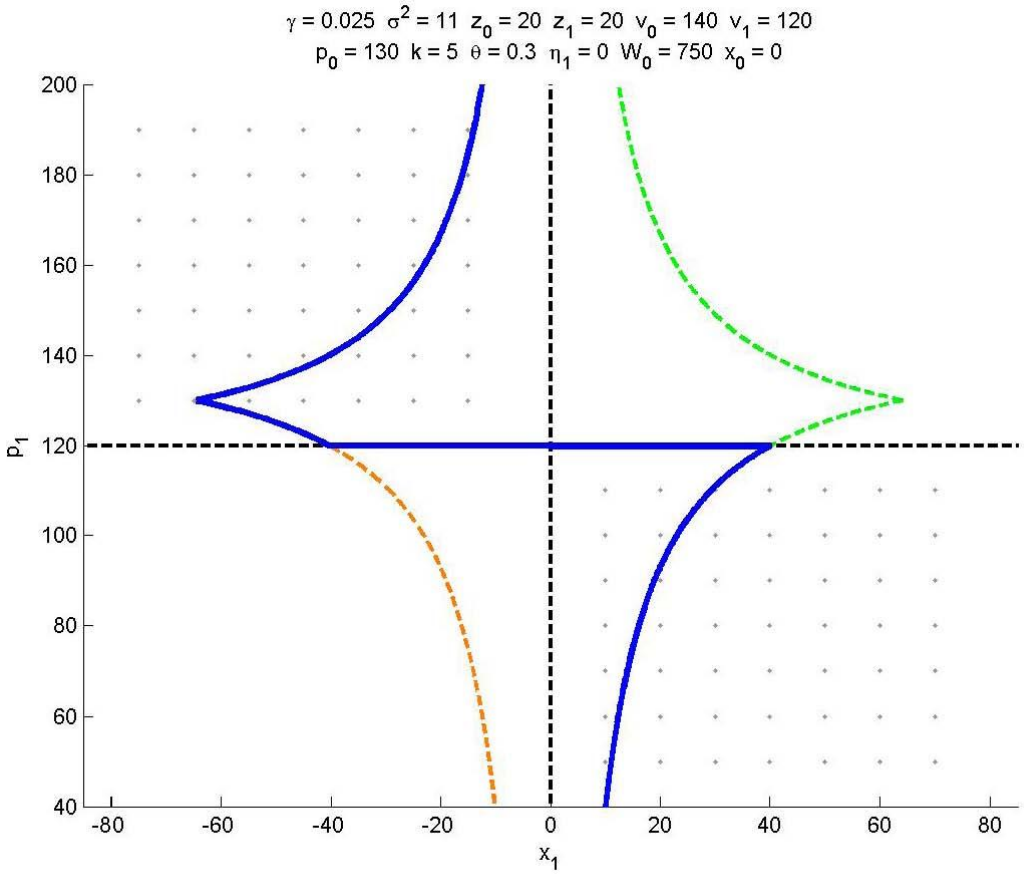
- Speculators go to their limits: W/(σ+|Δp|)



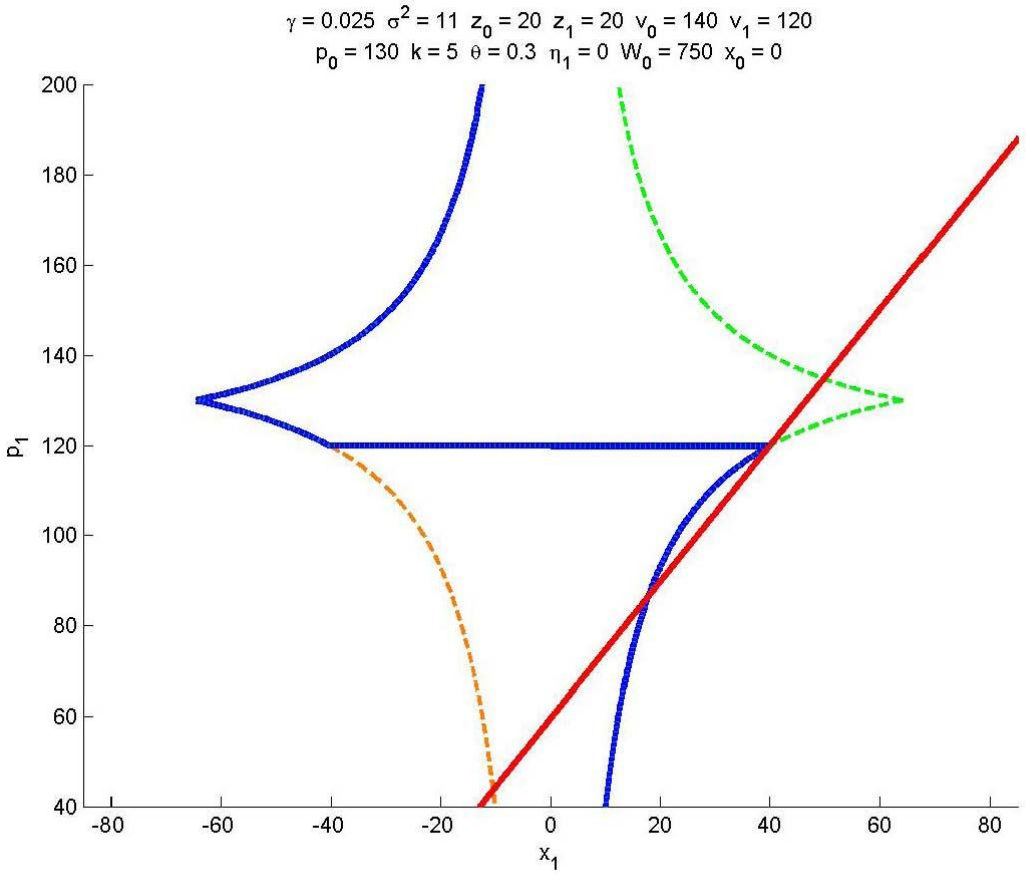
# Hyperbolic Star – relevant regions



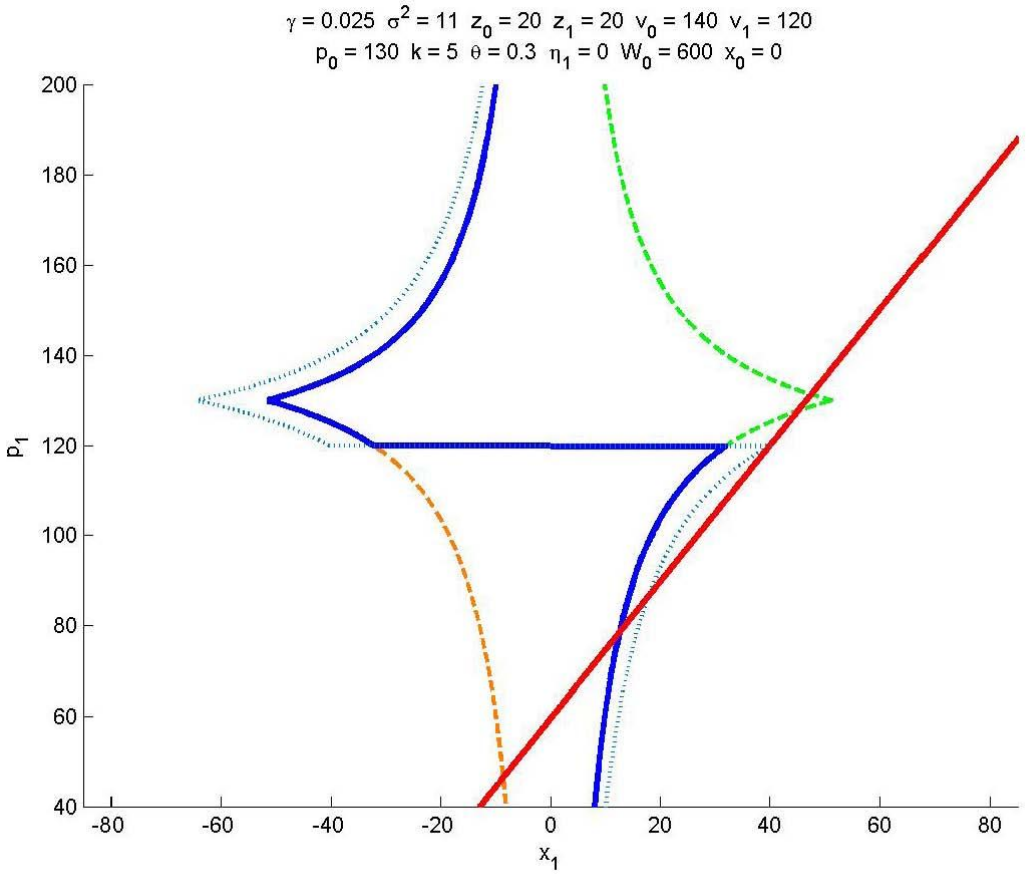
# Speculator demand



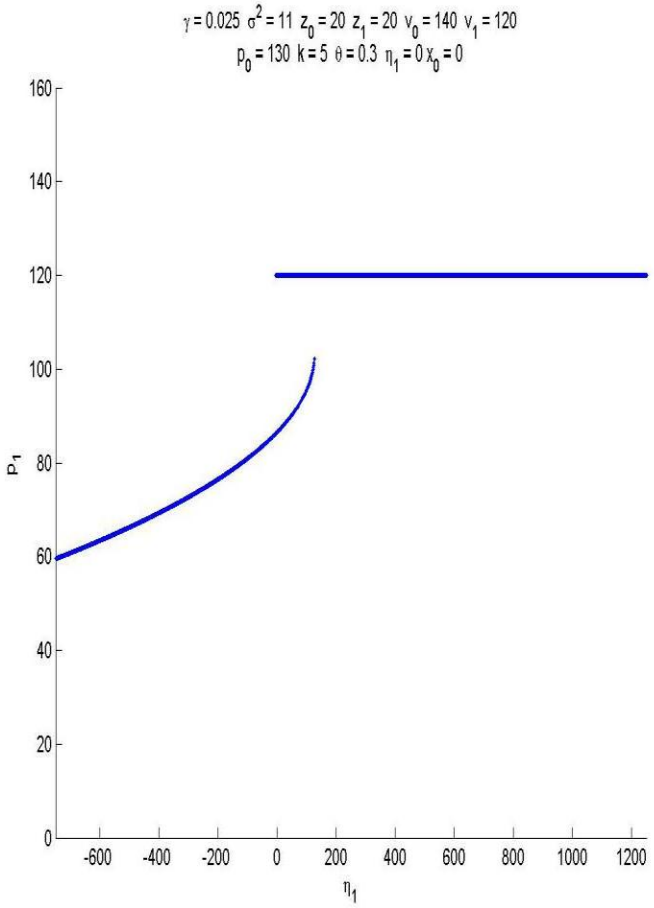
# Adding Customers' Supply

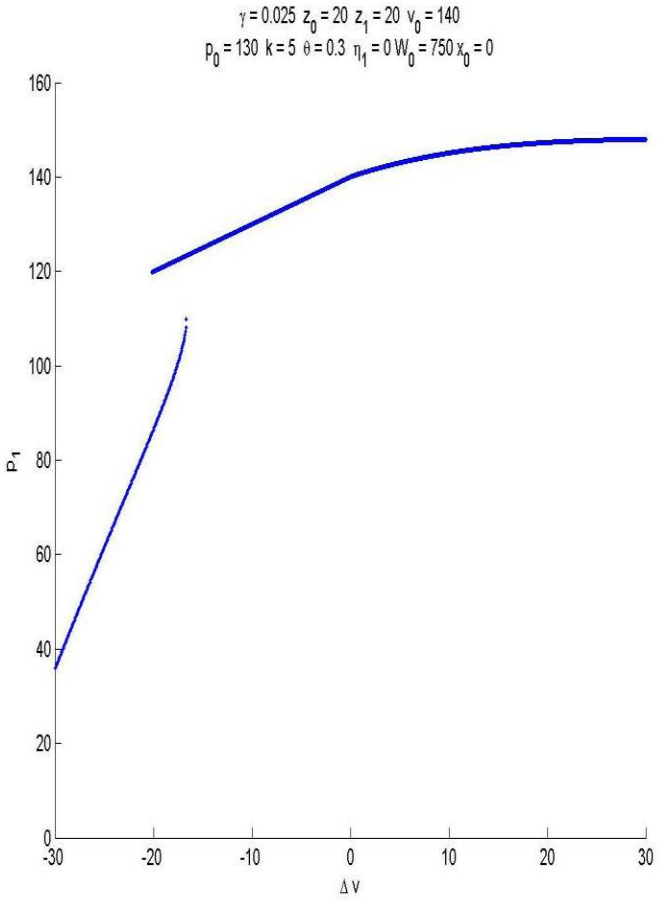


# Reducing Speculators' Wealth



# Fragility – due to multiple equil.



# Liquidity spirals

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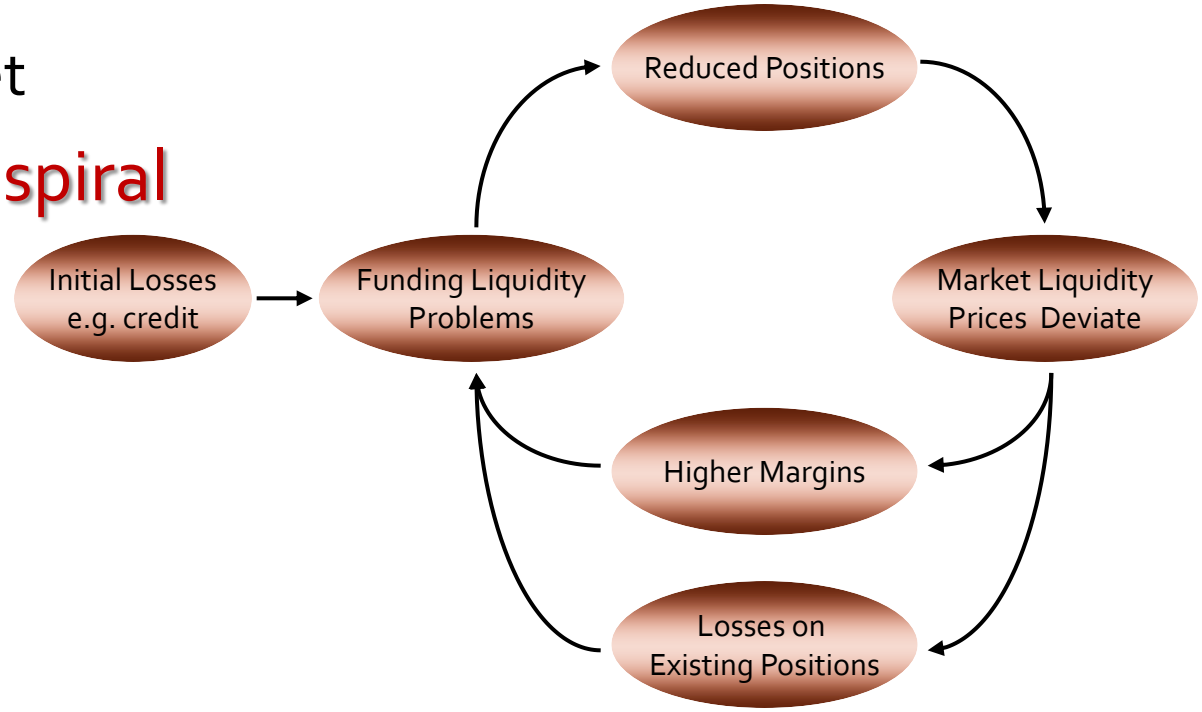
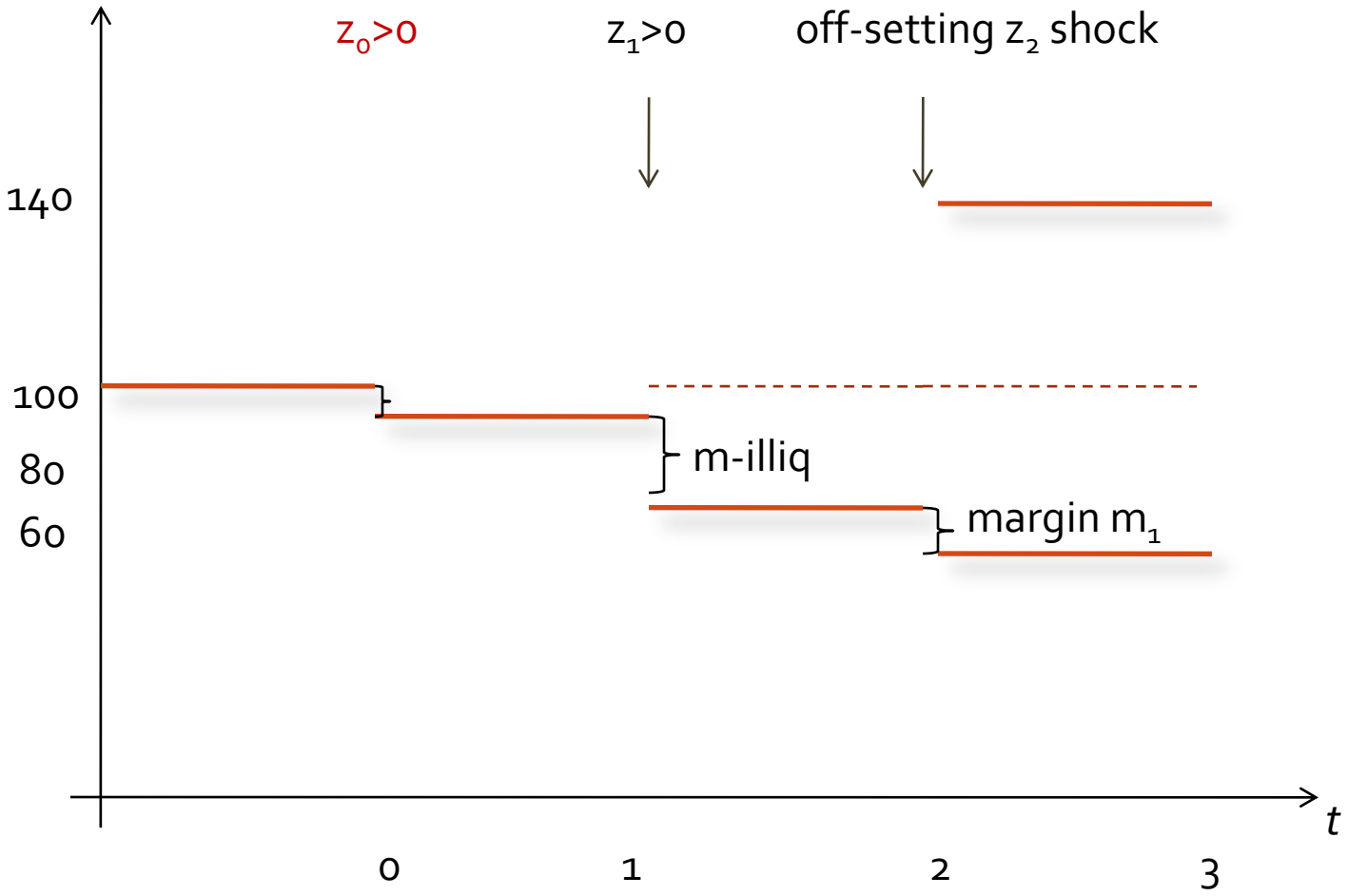



Brunnermeier-Pedersen (2009)

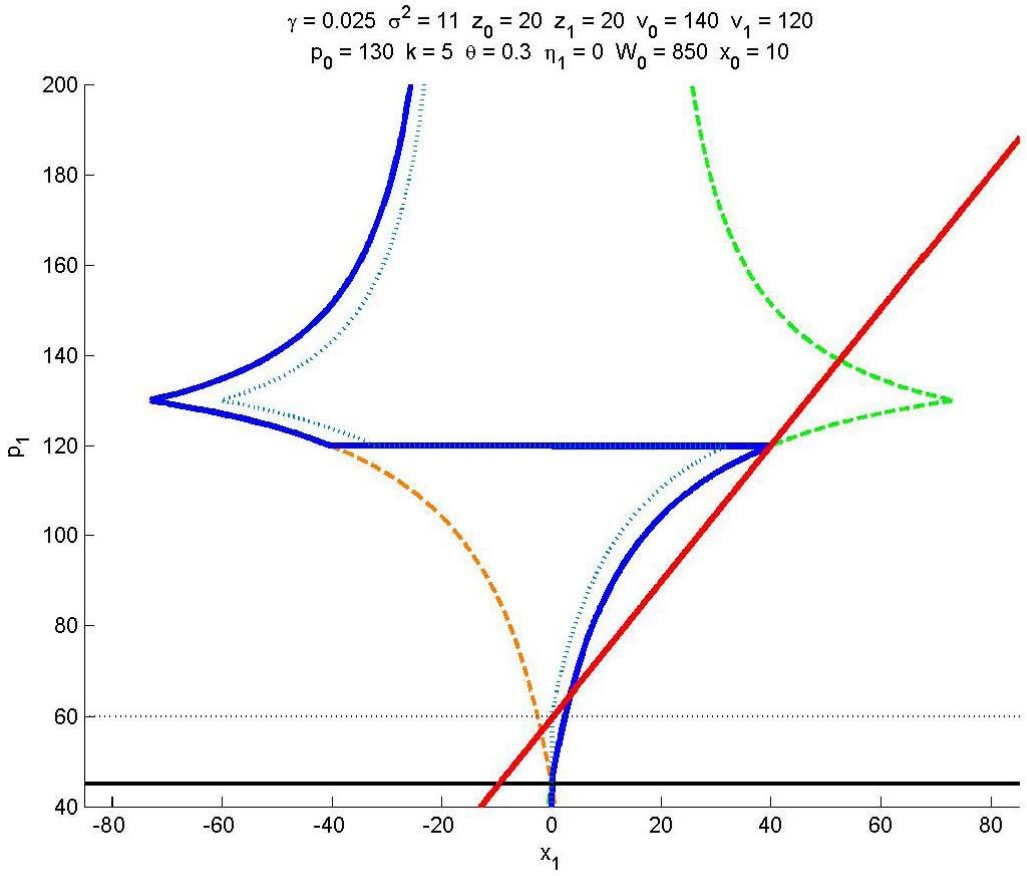
# Overview

- Fragility ⇒ multiple equl. (Endogeneity of systemic risk)
- Liquidity spirals
  - Loss spiral
  - Margin/haircut spiral ⇒ delevering ⇒ *Procyclicality*
- Fire sale externality - add period t=0
- Implications for financial regulation

# Model setup – now $z_0>0$



# 'Tilted' Hyperbolic Star at t=1 if $x_0$=10



# Main insights

1. Pricing kernel depends on future funding liquidity

$$p_0 = E_0[\underbrace{\frac{\phi_1}{E_0[\phi_1]}}_{\text{kernel}} p_1], \text{ if } \phi_0 = 1 \text{ (unconstrained case)}$$

$$p_0 = E_0[\phi_1]E_0[p_1] + Cov_0[\frac{\phi_1}{E_0[\phi_1]}, p_1]$$

2. Price $p_1$ distribution is skewed
   - Likely small increase
   - Unlikely large drop
   - (since speculators will be constrained and have to fire-sell their assets)Hold Price
3. Price in t=o is depressed even when speculators are not constrained, since
   - Speculators hold money on the side-line
   - Too little in good times due to fire-sale externality

# Main insights – fire-sale externality

- When levering up, institution *i* does not take into account that fire-sale depresses price of others
  - triggers liquidity spirals (loss and margin spiral)
- Precunariy externality that leads to inefficiency in incomplete market setting

- Other externalities
  - Hoarding externality
  - Runs (dynamic co-opetition)
  - Network externality
    (hide own commitments)

# Overview

- Fragility
- Liquidity spirals
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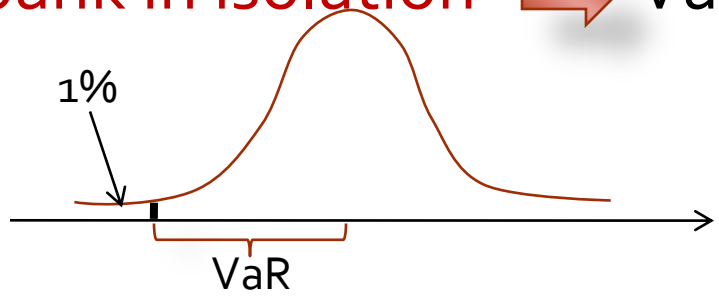
  - Margin/haircut spiral → delevering → *Procyclicality*
- Fire sale *externality*
- Implications for financial regulation
  - Focus on *externalities* – measure CoVaR
  - Countercyclical regulation
  - Incorporate funding side

# Current financial regulation

1. Risk of each bank in isolation ➡ Value at Risk




2. Procyclical capital requirements
3. Focus on asset side of the balance sheet matter
4. Focus on banks – shadow banking system

# Two challenges ….

1. Focus on externalities – systemic risk contribution
   - What are the externalities?
   - How to measure contribution to systemic risk?
     - CoVaR influences
       - Who should be regulated? (AIG, …) = functional approach
       - What is the optimal
         - capital charge (cap),
         - Pigouvian tax
         - Private insurance scheme?
2. Countercyclical regulation
   - How to avoid procyclicality?

+ incorporate liquidity risk – asset-liability interaction

# CoVaR

- CoVaR = VaR conditional on
  institute *i* (index) is in distress (at it's VaR level)

- Exposure CoVaR
  - Q1: Which institutions are most exposed if there is a systemic crisis?

  ⇒ $VaR^{i} \mid$ system in distress

- Contribution CoVaR
  - Q2: Which institutions contribute (in a non-causal sense)

  ⇒ $VaR^{system} \mid$ institution *i* in distress

| Cover both types | Institutions |
|---|---|
| Risk spillovers | "individually systemic" |
| Tail risk correlations | "systemic as part of a herd" |

  - Non-causal, can be driven by common factor

# Quantile Regressions: A Refresher

- OLS Regression: min sum of squared residuals

$$\beta^{OLS} = \arg\min_{\beta} \Sigma_t \left( y_t - \alpha - \beta x_t \right)^2$$

- Quantile Regression: min weighted absolute values

$$\beta^{q} = \arg\min_{\beta} \Sigma_t \begin{cases} q\left|y_t - \alpha - \beta x_t\right| & \text{if } \left(y_t - \alpha - \beta x_t\right) \geq 0 \\ (1-q)\left|y_t - \alpha - \beta x_t\right| & \text{if } \left(y_t - \alpha - \beta x_t\right) < 0 \end{cases}$$

# Quantiles = - Value-at-Risk

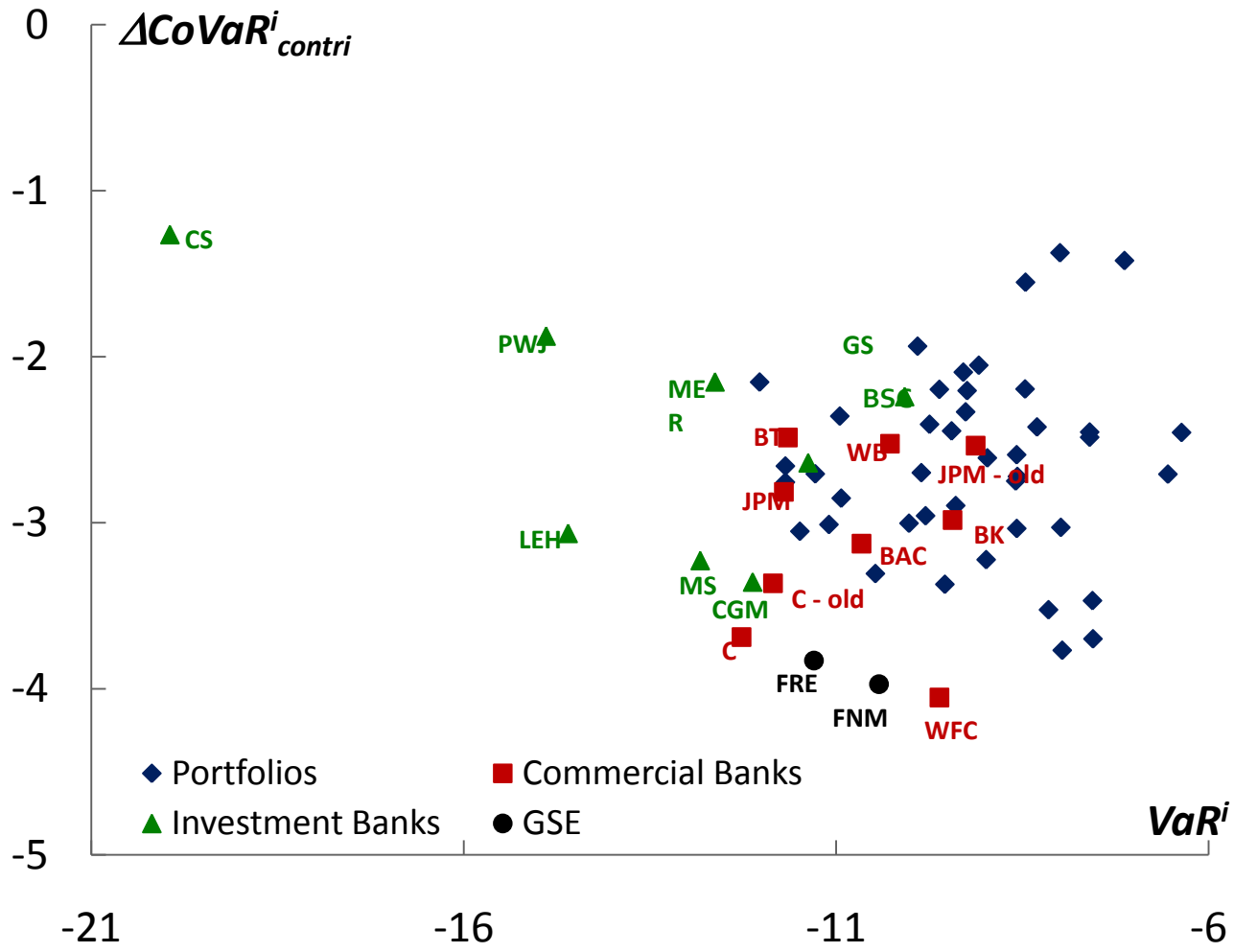
- Quantile regression:
  - Quantile *q* of *y* as a linear function of *x*

$$\hat{y}_q \mid x = F_y^{-1}(q \mid x) = \alpha_q + \beta_q x$$

where $F^{-1}(q|x)$ is the inverse CDF conditional on x

- Hence, $F^{-1}(q|x)$ = *q*% Value-at-Risk conditional on *x*.
  - Note out (non-traditional) sign convention!

# Q2: Who "contributes" to systemic risk?




- VaR does not capture systemic risk contribution $\Delta$ CoVaR$_{contri}$
- Data up to 2007/12

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- Fire sale *externality*
- Implications for financial regulation
  - Focus on *externalities* – measure CoVaR
  - Addressing procyclicality
    - Step 1: time-varying CoVaR
    - Step 2: Predictive regressions
      - Accounting variables of institutions (+interdependence, crowdedness)
      - Market variables of institutions

# Time-varying CoVaR

- Relate to macro factors — interpretation
  - VIX Level — "Volatility"
  - 3 month yield
  - Repo – 3 month Treasury — "Flight to Liquidity"
  - Moody's BAA – 10 year Treasury — "Credit indicator"
  - 10Year – 3 month Treasury — "Business Cycle"
  - House prices (home builder index)
  - (Aggregate Credit growth/spread)
  - (Haircut/margins (LTC ratios))

*… let's figure out what matters!*

- Obtain Panel data of CoVaR
  - Next step: Relate to institution specific (panel) data

# Predictive (1 year lag)

PANEL A: INSTITUTIONS

PANEL B: PORTFOLIOS

| | $CoVaR^i_{contri}$ | | $CoVaR^i_{exp}$ | | $CoVaR^i_{contri}$ | | $CoVaR^i_{exp}$ | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) |
| | FE, TE | FE | FE, TE | FE | FE, TE | FE | FE, TE | FE |
| VaR (lag) | 0.02** | 0.05*** | -0.06** | 0.03* | 0.20*** | 0.14*** | | -0.26*** |
| Mat-Mism(lag) | -0.30 | -0.30 | -1.84** | -1.79** | 1.20*** | 0.25 | | 0.04 |
| Leverage (lag) | -0.02*** | -0.02*** | -0.01 | -0.02 | -0.01*** | -0.04*** | | -0.01* |
| B/M (lag) | -0.27** | -0.19** | -0.08 | 0.71*** | -0.14 | 0.57*** | | -0.53*** |
| Size (lag) | 9.94 | 10.61 | 27.43* | -15.68 | -0.52 | -1.34 | | 2.52 |
| Constant | -0.35 | -0.65** | -5.04*** | -3.84*** | -0.55** | -0.63*** | | -6.13*** |
| Observations | 1657 | 1657 | 1657 | 1657 | 2486 | 2486 | | 2486 |
| R-squared | 0.66 | 0.40 | 0.62 | 0.48 | 0.72 | 0.38 | | 0.71 |

# Predicting with Market Variables

| | ΔCoVaR_contrib | | | | ΔCoVaR_exp | | | |
|---|---|---|---|---|---|---|---|---|
| COEFFICIENT | 1 Quarter | 1 Year | 1 Quarter | 1 Year | 1 Quarter | 1 Year | 1 Quarter | 1 Year |
| CDS_beta (lag) | -0.25*** | -0.58** | | | -1.24*** | -2.54*** | | |
| | (0.05) | (0.23) | | | (0.39) | (0.85) | | |
| ΔCDS (lag) | 0.05 | 0.06 | | | 1.39 | -1.28 | | |
| | (0.17) | (0.68) | | | (1.10) | (2.20) | | |
| IV_beta (lag) | | | -0.34*** | -0.67*** | | | -1.75*** | -3.33** |
| | | | (0.11) | (0.18) | | | (0.30) | (1.39) |
| DIV (lag) | | | -0.05 | -0.77*** | | | 0.63 | -0.56 |
| | | | (0.28) | (0.19) | | | (0.59) | (1.04) |
| Constant | -1.17*** | -1.28*** | -1.13*** | -1.15*** | -4.65*** | -4.82*** | -4.33*** | -4.20*** |
| | (0.04) | (0.07) | (0.07) | (0.08) | (0.15) | (0.24) | (0.17) | (0.52) |
| Observations | 178 | 148 | 178 | 148 | 178 | 148 | 178 | 148 |
| R-squared | 0.59 | 0.54 | 0.55 | 0.55 | 0.71 | 0.68 | 0.72 | 0.65 |

1) beta w.r.t. first principal component on changes in CDS spreads within quarter
2) panel regression with FE – (no findings with FE+TE)

# Conclusion

- Multiple equilibria (fragility)
  - Systemic risk is endogenous
- Liquidity spirals
  - Margin/haircut spiral leads to ***procyclicality***
- Fire-sale ***externality***

- Financial Regulation
  - Macro-prudential has to focus on externality
    CoVaR is one measure
  - Predict future CoVaR
    to overcome procyclicality
    due to delevering triggered by margin/haircut spiral