Princeton Initiative: Macro, Money and Finance

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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**
- Price stability
  Monetary policy

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

- Financial stability
  Macroprudential policy

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

- Fiscal debt sustainability
  Fiscal policy
Methodology

- **Verbal Reasoning** *(qualitative)*
  - Fisher, Keynes, ...

### Macro
- **Growth theory**
  - *Dynamic (cts. time)*
  - *Deterministic*
- **Introduce stochastic**
  - *Discrete time*
    - Brock-Mirman, Stokey-Lucas
    - DSGE models
- **Cts. time macro with financial frictions**

### Finance
- **Portfolio theory**
  - *Static*
  - *Stochastic*
- **Introduce dynamics**
  - *Continuous time*
    - Options Black Scholes
    - Term structure CIR
    - Agency theory Sannikov

timeline
Pre-crisis Macro

- Price/wage rigidities

Post-crisis Macro & Finance

- Financial frictions

- Expectations of cash flow
  - “the” short-term interest rate

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

- Expectation hypothesis
- Credit spread = expected default

- Euler equation
  - Substitution effects

- Endogenous risk/volatility
  - e.g. runs, sudden stops, ...

- Risk premia time varying

- Term risk premia
- Credit risk premia

- Wealth redistribution
  - Income/wealth effect

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

- Rich-poor
  - Less productive
  - More patient
  - More risk averse
  - More pessimistic

- Limited direct lending due to frictions

- Friction $\rightarrow p_s MRS_s$ 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)*
  - Next periods volatility *(VaR, JG)*
  - Current price

- **Search Friction** *(DGP)*
Liquidity Concepts

- Financial instability arises from the fragility of liquidity

**Technological liquidity**
- Reversibility of investment

**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 mismatch* determines severity of amplification, (sunspot) runs, ... “strategic complementarities”
Overview

- Types of distortions/frictions
- Run-up phase
  - Distorted beliefs
  - Concentration of risk
- Crash phase
  - Fire-sales
  - Paradox of Prudence
  - Spillovers
- Recovery phase
  - Persistence vs. Resilience
  - Dynamic Amplification
  - Volatility Dynamics/Volatility Paradox
- Welfare/Regulation

- Why continuous time modeling?
The 2 Components of Systemic Risk

1. Systemic risk build-up during (credit) bubble
   ... and materializes in a crisis
   - “Volatility Paradox” contemp. measures inappropriate
   - Vulnerability focus instead of timing focus

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

3. Persistence/Slow recovery

Shock to capital → Loss of net worth → Precaution + tighter margins

Fire sales

volatility price

nonlinearity
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
Run-up 1: Beliefs “Distortions”

- Representativeness heuristic/Diagnostic beliefs:
  - As if error terms followed AR(1)
  - 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

- Heterogeneous beliefs: optimists and pessimists

“consensus beliefs” ≠ marginal buyer’s beliefs
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- **Heterogeneous beliefs:** optimists and pessimists
  - + limited commitment ⇒ Leverage cycle
  - “Marginal buyer” vary with shocks

- Surveys elicit “**consensus beliefs**” ≠ **marginal buyer’s beliefs**
Run-up 1: Beliefs “Distortions”

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- **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
Run-up 2: Concentration of Risk

- **Belief extrapolation:**
  - No risk concentration necessary

- **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 2: Concentration of Risk

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  - “Experts” hold most of aggregate risk in good times
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  - **Credit cycle:** (BGG/KM/BruSan)
    - Experts save their way out of constraint after string of good shocks
    - Buffer against crisis
  - **Leverage cycle:** (JG/BruPed)
    - Most concentrated risk after string of good shocks
  - 2 key differences (besides hetero. beliefs):
    - More than two groups
    - Bubble don’t burst, but deflate
      - Worst case moves up
      - Higher debt capacity
Run-up 3: Maturity Mismatch

- Leverage cycle: worst case payoff isn’t as bad
  - Less disagreement => Better financing term
- Brunnermeier-Oehmke: Maturity “rat race”
  - Incentive to dilute creditors
- Diamond-Dybvig: Demand for liquidity
- Calomiris-Kahn: Discipline for banker
Absorbers vs. amplifier

- **Shock absorber**
- **Shock amplifier**

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<tr>
<th>Direct</th>
<th>Indirect</th>
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<tr>
<td><strong>Contractual links</strong></td>
<td>“Virtual links”</td>
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<tr>
<td>Loss through bankruptcy/default</td>
<td>Similar exposure than other levered players</td>
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<td><strong>Position data</strong></td>
<td><strong>Response indicator</strong></td>
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<td>- expectations/constraints</td>
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Distribution

- exogenous
- endogenous

Fat tail

Depends on strategic substitutability/complementarity
Spillovers

**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
  \[
  \frac{\partial u_i}{\partial x^i} \frac{\partial x^i}{\partial x^{-i}}
  \]
  - If others sell, it is more profitable for me to also sell
  - Descriptive/positive theory
Externality: negative

- \( x \)

\( i \)'s best response

\( \) negative externality

others' average actions
Externality: positive

- $x$

\[ i\text{'s best response} \]

\[ \text{others' average actions} \]

Positive externality
Strategic substitutability

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

If others respond less, (price goes down)
You respond less (buy less)
Lesson 1:

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

and

- Strategic Complementarity/Substitutability

\[ \frac{\partial}{\partial x^{-i}} \frac{\partial u^i}{\partial x^i} = \frac{\partial}{\partial x^{-i}} \frac{\partial u^i}{\partial x^{-i}} \]

can be independent of each other

Note: if \( \frac{\partial u^i}{\partial x^{-i}} = 0 \), then \( \frac{\partial}{\partial x^{-i}} \frac{\partial u^i}{\partial x^i} = 0 \)
Shock prior to run-up of imbalances

Strategic substitutability

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

Shock absorber
Shock prior to run-up of imbalances

Shock by 10, but equilibrium declines only by 9
Run up of imbalances

Strategic complementarities

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

Shock amplifier

Only off equilibrium changes (price is still high, but …)
Shock after run-up

Shock by 10
Leads to equilibrium effect of 30
2nd, 3rd round effects: Amplification

\[ i \text{'}s \text{ best response} \]

- Amplification
- Shock
- Run-up

Others' average actions
2\textsuperscript{nd}, 3\textsuperscript{rd} round effects: Amplification

Multiplicity
2\textsuperscript{nd}, 3\textsuperscript{rd} round effects: Amplification

Multiplicity
Strategic complementarities

If others were to respond less,
You also respond less

Even stronger (slope >1)
Drop without shock

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

"i"s best response

Run-up

others’ average actions
"Remember that hurricane a thousand miles away? That was me!"
Example: Leverage/Margin Funding

- action/holdings of “expert traders”
- residual supply $S(p)$

⇒ higher holding, higher price

Graph:
- i’s best response
- others’ average actions

$S(p)$ function showing relationship between actions and price.
Example: Leverage/Margin Funding

- Starting point

\[ i \text{’s best response} \]
Example: Leverage/Margin Funding

- After a small (fundamental shock)

"small shock absorber"
Example: Leverage/Margin Funding

- After a large (fundamental) shock

"small shock absorber"
"large shock amplifier"
Endogenous Fat Tails

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

- Starting point

- $i$’s best response
Leverage Increase

- Higher leverage
Leverage Increase

- After small shock
Increase in Leverage or Liquidity Mismatch

- Margin spiral ⇒ more strategic complementarity
Overview

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- Why continuous time modeling?
Liquidity Spirals – Amplification effects

- Loss Spiral
- Margin Spiral

Shock to capital → Loss of net worth → Precaution + tighter margins → Fire sales

nonlinearity

volatility price
Crash 1: Fire Sales

- Definition: Assets transferred to second-best users
- BGG: No second-best user
- KM: Negative shock ⇒ Experts sell to HH (gatherers), “Market illiquidity”

- Shleifer-Vishny (1992):
  - Fire sales ⇒ GE debt capacity matters
  - Restructuring > Fire sales

- Are fire-sales good or bad?
  - BruSan: Two competing effects
    - Ex-post: Fire sales stabilize economy in crisis, but misallocation
    - Ex-ante: Lead to excessive leverage (fire-sale/pecuniary externality) (Stein et al.,...
Fire-sales and Welfare

- Are fire-sales good (stabilizing) or bad (misallocation)
Crash 2: Leverage Dynamics

- Impulse Response curves:
  - Amplification

- 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
Crash 2: 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 HF in Ang et al. (2011)
    - HF procyclical, investment banks countercyclical
US Repo Run? 2008/9

- Margins on collateral assets
  - very stable in tri-party repo market
    - 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.
Bilateral and Tri-party Haircuts/Margins?

Differences in Median Haircuts

Source: FRBNY Calculations
Gorton & Metrick (2011)

- Bilateral repo data (private date by Gorton)
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
ABCP market—Money market funds

- Buyers of Asset Backed Commercial Paper: Money market funds
- Established as an alternative to bank deposits with higher interest
  - No FDIC insurance
  - But break the buck-rule (useful marketing device)
- Forces money market funds, to delever when price declines
  - Creates upward sloping demand curve
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, ...

![Commercial Paper Graph](image-url)
Crash 3: Paradox of Prudence

“Micro-prudence” of bank is “macro-imprudent”

- Liquidity spiral (price of capital)
- Disinflationary spiral (price of money)
- Banks issue less inside money (& diversify less risk)
- HH demand more money
Crash 3: Paradox of Prudence

- “Micro-prudence” of bank is “macro-imprudent”
- Two “spirals” amplify
  - Liquidity spiral (price of capital)
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⇒ Lower inflation

BruSan “The \( I \) Theory of Money”
Crash 4: Spillovers Across Assets

- Belief extrapolation: No spillovers
  - Unless “baked-in” in beliefs

- Net worth channel:
  - BGG/KM BruSan: Expert net worth affects all assets
  - Diamond-Rajan (2005)
  - JG-Leverage cycle: Spillovers from “crossover” investors
    - 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
Diamond Dybvig Runs

- Market Financing
  - Brunnermeier & Pedersen

- Traditional Banks
  - Diamond Dybvig
Bank run 

- 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

- Fire-sales of tradable assets
- Risk shifting towards depositors (insurance)
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- Why continuous time modeling?
Speed of Recovery

- Speed of Recovery
  - KM: deterministic
  - BruSan: Length of recession is stochastic
    $\Rightarrow$ precautionary savings
Recovery from Crisis/Resilience

- Belief extrapolation: Recovery speed determined by belief persistence
  - Perceived AR(1) coefficient on errors

- BGG/KM: Recovery in tandem with experts’ balance sheets

- JG: Recovery with experts’ balance sheets & disagreement/volatility
  - Less disagreement ⇒ Lower margins ⇒ Higher marginal buyer

- BruSan: Length of recovery is stochastic
  ⇒ additional precautionary savings
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*
  - Carlstrom & Fuerst (1997)
  - Bernanke & Gertler (1989)
- 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 $t + 2$, ...
- Decrease in capital supply also leads to
  - Increased price of capital $q_t$
  - Dampening effect on propagation of net worth shock
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.
BGG assume separate investment sector
- This separates entrepreneurs’ capital decisions from adjustment costs

Φ(·) represents technological illiquidity
- Increasing and concave with Φ(0) = 0
- $K_{t+1} = Φ\left(\frac{I_t}{K_t}\right)K_t + (1 - δ)K_t$

FOC of investment sector
- $\max_{I_t} \{q_tK_{t+1} - I_t\} \Rightarrow q_t = 1/Φ'\left(\frac{I_t}{K_t}\right)$
Shocks to net worth \( N_t \) are persistent
- They affect capital holdings, and thus \( N_{t+1}, \ldots \)

*Technological illiquidity* for capital “demanders” now introduces amplification effect
- Decrease in capital leads to reduced price of capital from \( q_t = \frac{1}{\Phi' \left( \frac{I_t}{K_t} \right)} \)
- Lower price of capital further decreases net worth
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
“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 fat tails, skewness

- Volatility Paradox
  - Low exogenous (measured) volatility leads to high build-up of (hidden) endogenous volatility (Minsky)
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Financial Regulation/Welfare Criterion

- Important macro-prudential tools:
  - Countercyclical buffer, liquidity regulation, LTV, DTI, spillover metric,

- Belief extrapolation (mean dynamics):
  - Paternalistic: lean against price movements (all the time)

- Heterogeneous beliefs
  - JG: Financial innovation causes boom & bust (no welfare loss risk-neutral)
  - Speculation: Tobin tax insufficient?
  - Welfare criterion (BSX)

- Fire-sale externality/spillovers (CoVaR measure)

- Loosen borrowing constraints in bad times (BGG/KM)

- Also control concentration of risk in good times (JG/BruSan)
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Why continuous time modeling?

- Characterization for volatility and amplification
  - Discrete: only impulse response functions
    - Only for shocks starting at the steady state
    - Only expected path – fan charts help somewhat

- More analytical steps
  - Return equations
    - Next instant returns are essentially log normal (easy to take expectations)
  - Explicit net worth and state variable dynamics
    - Continuous: only slope of price function determines amplification
    - Discrete: need whole price function (as jump size can vary)

- Numerically simple – solve differential equations
- Discrete: IES/RA within period $= \infty$, across periods $\frac{1}{\gamma}$
Cts. time: special features of diffusions

- Continuous path – fast enough deleveraging
  - Never jumps over a specific point, e.g. insolvency point
- Implicit assumption: can react to small price changes
  - Can continuously delever as wealth goes down
  - Makes them more bold ex-ante
Recent Macro-finance Literature (in cts. time)

- **Core**

- **Intermediation/shadow banking**

- **Quantification**
  - He & Krishnamurthy (2014), Mittnik & Semmler (2013)

- **International**
  - BruSan (2015), Maggiori (2013)

- **Monetary**
  - “The I Theory of Money” (2012), Drechsler et al. (2014)

- ...
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