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
Systemic risk – a broad definition

- Systemic risk build-up during (credit) bubble ... and materializes in a crisis
  - “Volatility Paradox” → contemp. measures inappropriate

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

**Adverse GE response** → amplification, persistence
Minsky moment – Wile E. Coyote Effect

Time-series
Systemic Risk Measures

Cross-section

- Risk measures
  - VaR, Expected Shortfall, ….

- Systemic Co-Risk Measures
  - CoVaR  (Adrian-Brunnermeier 2010)
    VaR of financial system conditional that Lehman is at its VaR
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
### Pre-crisis Macro emphasis

- Price/wage rigidities
- 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

### 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
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
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"
Safe Assets: various definitions

1. Safe = risk-free for a particular horizon
   - e.g. holders are infinitely risk averse
   - ... but inflation risk
   - Caballero & Farhi

2. Safe = informationally insensitive
   - No decline in value due to asym. info
   - Holmstrom & Gordon

3. Safe = “good friend analogy”
   - Safe for random horizon
   - Appreciates in times of crises
   - Brunnermeier & Haddad

Safe = “safe asset tautology”
   - Safe because perceived to be safe
   - Bubble
Safe assets & money: close cousins

- **Store of value**
  - Safe asset
    - Pool of risky high yield assets
  - Deposits
    - Equity

- Held in addition to risky assets
- Held in order to produce (private) safe assets

- **Reference/benchmark asset**
- **Good collateral: stable margins**

- store of value
- unit of account
- transaction role
Safety versus Risk

- US Treasury downgraded by S&P (due to default risk)
  - ... but yield declines
- German CDS spread versus yield during Euro crisis

![German Sovereign 5Y CDS and 10Y Yield](image)

Source: Bloomberg
The “Curse of Safety” with Haddad

- **Investment equilibrium**
  - High real investment
  - High market liquidity of risky assets
    - Less safe asset holdings necessary

- **Safety equilibrium**
  - Low real investment
  - Low market liquidity of risky assets
    - High safe asset holdings necessary

Reverses policy implications!
Financial frictions

- Incomplete markets
  - Micro-foundation for only debt contracts:
    - Costly state verification (BGG)
    - Skin in the game constraint

- Leverage constraints
  - Exogenous limit (Bewley/Ayagari)

- Collateral constraints
  - Next period’s price (KM)
    \[ Rb_t \leq q_{t+1}k_t \]
  - Next periods volatility (VaR)
  - Current price

\[ \text{Debt limit can depend on prices/volatility} \]
Constraints vs. Incomplete Markets
Constraints vs. Incomplete Markets

state 1

state 2

Bond/debt
Constraints vs. Incomplete Markets

Short-sale constraint
Constraints vs. Incomplete Markets

Short-sale constraint

state 1

state 2
Constraints & Incomplete Markets

2\textsuperscript{nd} example:

Debt limit can depend on prices/volatility
Amplification vs. inefficiency

- Amplification/ multiplicity: Strategic complementarities

- Inefficiencies: externalities

Positive economics

Normative economics
Macro-literature on Frictions

1. Net worth effects:
   a. Persistence: Carlstrom & Fuerst
   b. Amplification: Bernanke, Gertler & Gilchrist
      “Kocherlakota critique”

2. Volatility effects: impact credit quantity constraints
   a. Margin spirals: Brunnermeier & Pederson
   b. Endogenous constraints: Geanakoplos

3. “Self-insurance”: Liquid, safe assets, money, bubbles
   a. OLG, Aiyagari, Bewley, Krusell-Smith, Holmstrom-Tirole...
   b. Brunnermeier & Sannikov volatility dynamics

4. Financial intermediaries – The I Theory of Money
Amplification & Instability - Overview

  - Perfect (technological) liquidity, but persistence
  - Bad shocks erode net worth, cut back on investments, leading to low productivity & low net worth of in the next period
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  - Technological/market illiquidity
  - KM: Leverage bounded by margins; BGG: Verification cost (CSV)
  - Stronger amplification effects through prices (low net worth reduces leveraged institutions’ demand for assets, lowering prices and further depressing net worth)

- Brunnermeier & Sannikov (2014)
  - Instability, volatility dynamics, volatility paradox, Kocherlakota critique

- Brunnermeier & Pedersen (2009), Geanakoplos
  - Volatility interaction with margins/haircuts (leverage)
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. 

Jump
CSV: Contracting

- Competitive market for capital
  - Lender’s expected profit is equal to zero
  - Borrower’s optimization is equivalent to minimizing expected verification cost

- Financial contract specifies:
  - Debt repayment for each reported outcome
  - Reported outcomes that should be verified
CSV: Optimal Contract

- Incentive compatibility implies that
  - Repayment outside of VR is constant
  - Repayment outside of VR is weakly greater than inside
- Maximizing repayment in VR reduces the size and thus the expected verification cost
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
Brunnermeier, Eisenbach & Sannikov

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
- \( \Phi(\cdot) \) 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
  - \( \max_{I_t} \{ q_t K_{t+1} - I_t \} \Rightarrow q_t = 1/\Phi' \left( \frac{I_t}{K_t} \right) \)
BGG: Persistence & Amplification

- Shocks to net worth $N_t$ are persistent
  - They affect capital holdings, and thus $N_{t+1}$...
- *Technological illiquidity* for capital “demanders” now introduces amplification effect
  - Decrease in capital leads to reduced price of capital from
    \[ q_t = \frac{1}{\Phi'(\frac{I_t}{K_t})} \]
  - 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
Two types of infinitely-lived risk neutral agents

Mass $\eta$ of productive agents
- Constant-returns-to-scale production technology yielding $y_{t+1} = ak_t$
- Discount factor $\beta < 1$

Mass $1 - \eta$ of less productive agents
- Decreasing-returns-to-scale production $y_{t+1} = F(k_t)$
- Discount factor $\beta \in (\beta, 1)$

Note: Now, we have two different production functions!
Since productive agents are less patient, they will want to borrow $b_t$ from less productive agents.

- However, friction arises in that each productive agent’s technology requires his individual human capital.
- Productive agents cannot pre-commit human capital.

This results in a collateral constraint

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

- Productive agent will never repay more than the value of his asset holdings, i.e. collateral.
“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
BruSan14: Instability & Non-Linear Effects

- Previous papers only considered log-linearized solutions around steady state
- Brunnermeier & Sannikov (2014) build a continuous time model to study full dynamics
  - Show that financial system exhibits inherent instability due to highly non-linear effects
  - These effects are asymmetric and only arise in downturn
  - A shock can be followed by future shocks
    - Length of slump is uncertain
- Agents choose a *capital cushion*
  - Mitigates moderate shocks near steady state
  - High volatility away from steady state
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
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 literature (in most recent 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)

- …. 
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2. Volatility effects: impact credit quantity constraints
   a. Margin spirals: Brunnermeier & Pederson
   b. Endogenous constraints: Geanakoplos

3. Liquid, safe assets, money, bubbles – “self insurance”
   a. OLG, Aiyagari, Bewley, Krusell-Smith, Holmstrom-Tirole,...
   b. Brunnermeier & Sannikov volatility dynamics

4. Financial intermediaries
Credit Rationing – Quantity Rationing

- Credit rationing refers to a failure of market clearing in credit
  - In particular, an excess demand for credit that fails to increase market interest rate
  - Pool of loan applicants worsens
  - Stiglitz & Weiss (1981) show how asymmetric information on risk can lead to credit rationing
Entrepreneurs borrow from competitive lenders at interest rate $r$
- Risky investment projects with $R \sim G(\cdot | \sigma_i)$
- Mean preserving spreads, so heterogeneity is only in risk

Assume entrepreneur borrows $B$

Entrepreneur’s payoff is convex in $R$
- $\pi_e(R, r) = \max\{R - (1 + r)B, 0\}$

Lender’s payoff is concave in $R$
- $\pi_l(R, r) = \min\{R, (1 + r)B\}$
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Debt limit can depend on prices/volatility
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

These margin spirals force agents to delever in times of crisis
- Collateral runs
- Counterparty bank run
- Multiple equilibria
BP: Margins – Value at Risk (VaR)

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

- **Borrowers’ balance sheet**
  - **Loss spiral – net worth drops**
    - Net wealth > \( \alpha \times \) for asym. info reasons
    - Constant or increasing leverage ratio
  - **Margin/haircut spiral**
    - Higher margins/haircuts
    - No rollover
    - Redemptions
    - Forces to delever

- **Mark-to-market vs. mark-to-model**
  - Worsens loss spiral
  - Improves margin spiral

• Both spirals reinforce each other
1. Volatility of collateral increases
   - Permanent price shock is accompanied by higher future volatility (e.g. ARCH)
     - Realization how difficult it is to value structured products
   - Value-at-Risk shoots up
   - Margins/haircuts increase = collateral value declines
   - Funding liquidity dries up
   - Note: all “expert buyers” are hit at the same time, SV 92

2. Adverse selection of collateral
   - As margins/ABCP rate increase, selection of collateral worsens
   - SIVs sell-off high quality assets first (empirical evidence)
   - Remaining collateral is of worse quality
Data Gorton and Metrick (2011)

Haircut Index

“The Run on Repo”
Copeland, Martin, Walker (2011)

Margins **stable** in tri-party repo market
- contrasts Gorton and Metrick
- no general run on certain collateral

Run (non-renewed financing) only on select **counterparties**
- Bear Stearns (anecdotally)
- Lehman (in the data)

Like 100% haircut...
(counterparty specific!)
Bilateral and Tri-party Haircuts?

Differences in Median Haircuts

Percent

60
50
40
30
20
10
0
-10

Subprime
Alt-A, Prime MBS
High-Grade Corp Debt
Agency CMO
Treasury Agency GSE MBS

Source: FRBNY Calculations

Jul-08 Oct-08 Jan-09 Apr-09 Jul-09 Oct-09 Jan-10
BP: Commonality & Flight to Quality

- **Commonality**
  - Since funding liquidity is driving common factor

- **Flight to Quality/Safety**
  - Quality=Liquidity
    - Assets with lower fund vol. have better liquidity
  - Flight
    - Liquidity differential widens when funding liquidity becomes tight
$m^2 = \text{Volatility of Security}_2 = 2 > 1 = \text{Volatility of Security}_1 = m^1$

$\gamma = 0.015$  $z_0 = 20$  $z_1 = 20$  $\nu_0 = 140$  $\nu_1 = 120$
$\rho_0 = 130$  $\sigma_1 = 10$  $\sigma_2 = 15$  $\nu = 0.3$  $\eta_1 = 2000$  $x_0 = 0$
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