Introduction to Modern Macro, Money, and Finance

- Defining Macro-Finance
- Amplification, Persistence, Resilience
- Continuous Time Modeling
History of Macro and Finance

**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

**Verbal Reasoning** (qualitative)
- Fisher, Keynes, ...
What is Macro-Finance?

- **Macro**: aggregate impact (resource allocation and constraint)
- **Finance**: risk allocation
  - financial/contracting frictions, heterogeneous agents
  - institutions, liquidity
- **Monetary**: inside money creation

- **How to design** Financial Sector, Gov. bonds, etc.
  - to achieve optional resource and risk allocation

- **Topics include**:
  - Amplification, peculation of shocks, resilience, financial cycle
  - Financial stability, spillovers, systemic risk measures
  - (Un)conventional central bank policy and balance sheet, maturity structure, CBDC
  - Capital flows
What is Macro-Finance?
Heterogeneous Agents

- 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

- Friction $p_s MRS_s$ different even after transactions
- Wealth distribution matters! (net worth of subgroups)
- Financial sector is not a veil
Financial Frictions and Distortions

- Belief distortions
  - Match “belief surveys”

- Incomplete markets:
  - “natural” leverage constraint (*BruSan*)
  - Costly state verification (*BGG*)

- Leverage constraints
  - + Exogenous limit (Bewley/Ayagari)
  - Collateral constraint
    - Next period’s price (KM)
    - Next period’s volatility (VaR, JG)
    - Current price

- Search Friction (DGP)

\[
Rb_t \leq q_{t+1} k_t
\]
Financial Sector

- 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
Risk Premia, Price of Risk

- Risk premia = price of risk * (endogenous + exogenous risk)
  - Exogenous risk – shock from outside
  - Endogenous risk
    - Amplification: adverse feedback loops
    - Multiple equilibria: Run, Sudden Stops

- Non-linearities are key for financial stability
  - Around vs. away from steady state
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
Macro: Consumer vs. Finance Focused

Consumption decision
- Demand management at ZLB (liquidity trap) [interest rate drives consumption]
- Expectation: but no risk premia [expectations hypothesis, UIP, ...]
- Heterogeneity: wealth distribution across consumers (+ investors)

Investment and portfolio decision - Macro-finance
- Risk-free rate and risk premia [term-risk, credit risk premia]
- Risk-premia = price of risk * (exogenous risk + endogenous risk)
  \[ \Delta \text{price} = f(\Delta E[\text{future cash flows}, \Delta \text{risk premia}]) \]
- Heterogeneity: wealth distribution across investors (+ consumers)
## Cts.-time Macro: Macro-Finance vs HANK

<table>
<thead>
<tr>
<th>Agents</th>
<th>Heterogenous investor focus</th>
<th>Heterogenous consumer focus</th>
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<td>- Net worth distribution (often discrete)</td>
<td>- Net worth distribution (often cts.)</td>
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### Tradition:
- Finance (Merton)
  - Portfolio and consumption choice
  - Full/global dynamical system
  - Focused on non-linearities away from steady state (crisis ...)
  - Length of recession is stochastic

- DSGE (Woodford)
  - Consumption choice
  - Transition dynamics back to steady state
  - Zero probability shock
  - Length of recession is deterministic

### Money due to:
- Risk and Financial Frictions
  - Risk
  - Price stickiness
  - No aggregate risk (in HANK paper)

### Price of risk:
- Idiosyncratic and aggregate risk
  - N/A

### Assets:
- Capital, money, bonds with different risk profile
  - Risk-return trade-off
  - Liquidity-return trade-off
  - Flight to safety

- All assets are risk free
  - No risk-return trade-off
  - Liquidity-return trade-off
Policy: Objectives and Instruments

- **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
  - Taxes/subsidies

STABILITY
Overview

- Defining Macro-Finance
- Amplification, Persistence, Resilience
- Continuous Time Modeling
Persistence and Resilience

- 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.
Persistence Leads to Dynamic 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: grow net worth via retained earnings
  - Backward: asset pricing
“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)
Fan Charts & Endogenous Volatility Dynamics

lecture_slides/lec1/figs/XXX_a.png
Overview

- Defining Macro-Finance
- Amplification, Persistence, Resilience
- Continuous Time Modeling
Why Continuous Time Modeling?

- Time aggregation
  - Data come in different frequency
    - GDP quarterly
    - High frequency financial data

- Consumption
  - Same IES within and across periods
  - Discrete time consumption
    - IES/RA within period \( = \infty \), but across periods \( = 1/\gamma \)

- Optimal Stopping problems - no integer issues

- Sharp distinction between stock and flow (rate)
  - Beginning of period = end of period wealth
    - E.g. consumption = time-preference rate * end of period wealth
Brownian Motion $dZ$

- Brownian Motion as a binomial tree over $\Delta t$.
- More steps with shrinking step size: $h_n = \sigma \sqrt{\Delta t/n}$
Itô Processes: Characterization, Skewness over $\Delta t$

- Itô processes ... fully characterized by drift and volatility
  \[ dX_t = \mu(X_t, t)dt + \sigma(X_t, t)dZ_t \]
  - Arithmetic Itô’s Process: \[ dX_t = \mu X_t dt + \sigma X_t dZ_t \]
  - Geometric Itô’s Process: \[ dX_t = \mu_t X_t dt + \sigma_t X_t dZ_t \]

- Characterization for full volatility dynamics on Prob.-space
  - Discrete time: Probability loading on states
    conditional expectations $E[X|Y]$ difficult to handle
  - Cts. time Loading on a Brownian Motion $dZ_t$ captured by $\sigma$

- Normal distribution for $dt$, yet with skewed distribution for $\Delta t > 0$

- If $\sigma_t$ is time-varying
- E.g. from normal-$dt$ to log-normal-$\Delta t$ and vice versa (geometric $dX_t$.)

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Continuity of Itô Processes

- Continuous path
  - Information arrives continuously “smoothly” - not in lumps
  - Implicit assumption: can react continuously to continuous info flow
  - Never jumps over a specific point, e.g. insolvency point
  - Simplifies numerical analysis:
    - Only need change from grid-point to grid-point (since one never jumps beyond the next grid-points)
  - No default risk: Can continuously delever as wealth declines
    - Might embolden investors ex-ante
  - Collateral constraint
    - Discrete time: \( b_t R_{t,t+1} \leq \min\{q_{t+1}\} k_t \)
    - Cts. time: \( b_t \leq (p_t + dp_t) k_t \rightarrow 0 \)
      \( \text{For short-term debt – not for long-term debt ... or if there are jumps} \)

- Levy processes ... with jumps
  - Still price of risk * risk, but not linear
Conditional Expectations for Itô

- in discrete time:
  - e.g. \( \mathbb{E}_t[V(\eta)] \)
  - Need function \( V(\eta) \) across all states \( \eta \)
  - Simulate \( \eta \) to obtain probability weights for \( \eta \) all realizations

- in continuous time with Itô:
  \[
  \mathbb{E}[dV(\eta)] = V'(\eta) \mu_\eta \, dt + \frac{1}{2} V''(\eta) \sigma^2_\eta \, dt
  \]
  - Just need the two neighboring grid points instead of the whole function \( \rightarrow V''(\eta) \)

\[\text{ } \]
\[\begin{align*}
\begin{array}{c}
V'(\eta) \text{ is approximated by } \frac{V(\eta+\Delta)-V(\eta)}{\Delta} \text{ or } \frac{V(\eta)-V(\eta-\Delta)}{\Delta} ; \hfill \\
V''(\eta) \text{ by } \frac{V(\eta+\Delta)-V(\eta)-(V(\eta)-V(\eta-\Delta))}{\Delta^2} \hfill
\end{array}
\end{align*}\]

- Similar for price \( q(\eta) \)
  - Return equations: requires only slope of price function \( q(\eta) \) to determine amplification instead of whole price function across all \( \eta \) in discrete time.
Dynamic Portfolio Choice in Continuous Time

- **Portfolio choice** - tension in discrete time
  
  \[ R_t R_{t+1} \ldots = e^{r_t + r_{t+1} + \ldots} \]  
  log-normal returns

- **Portfolio**
  
  \[ \theta^1_t R_t^1 + \theta^2_t R_t^2 + \ldots \]
  
  normal returns

- Linearize \( \sigma \)-term, all assets are equivalent
- 2nd order approximation \( \sigma \) kills time-varying \( \sigma \)
- Log-linearize à la Campbell-Shiller

- As \( \Delta t \to 0 \) (log) returns converge to normal distribution
  
  - Constantly adjust the approximation point
  - Nice formula for portfolio choice for Ito process
Consumption Choice & Wealth (Share) Dynamics

- Consumption choice
  - Nice Process
    - consumption/wealth ratio is constant for log-utility, e.g. for log-utility
      \[ c_t = \rho N_t \]
    - Beginning = end of period net worth/wealth

- Evolution of state variables wealth (shares)/distribution
  - Nice Characterization
  - Evolution of distributions (e.g. wealth distribution) characterized by
    Kolmogorov Forward Equation (Fokker-Planck equation)
Conclusion

- Defining Macro-Finance
- “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, Endogenous. Volatility Dynamics
  - Resilience
- Advantages of Continuous Time Modelling