Eco529: Modern Macro, Money, and International Finance

Lecture 01: Introduction

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Introduction to Modern Macro, Money, and Finance

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

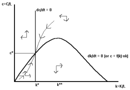
History of Macro and Finance

- *Verbal Reasoning* *(qualitative)*

Fisher, Keynes, ...

Macro

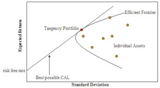
- Growth theory
  - *Dynamic (cts. time)*
  - *Deterministic*



- 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

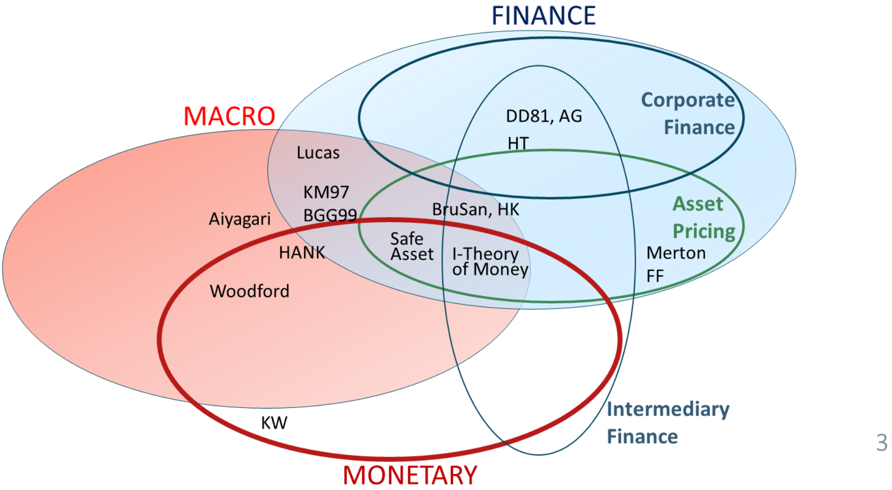
- Cts. time macro with financial frictions

What is Macro-Finance?

- Macro: aggregate impact (resource allocation and constraint)
- Finance: risk allocation
  financial/contracting frictions, heterogeneous agents
  $\Rightarrow$ 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

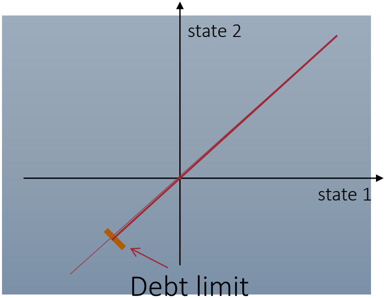
- Lending-borrowing/insuring since agents are different

▪ Poor-rich ▪ Productive ▪ Less patient ▪ Less risk averse ▪ More optimistic	Limited direct lending ↔ due to frictions	▪ 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
  (no "liquidity creation")
  - Exogenous limit (*Bewley/Ayagari*)
  - Collateral constraint
    - Next period's price (*KM*)
      $Rb_t \leqslant q_{t+1} k_t$
    - Next period's volatility (*VaR,JG*)
    - Current price
- Search Friction (*DGP*)



Debt limit
can depend on
prices/volatility

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

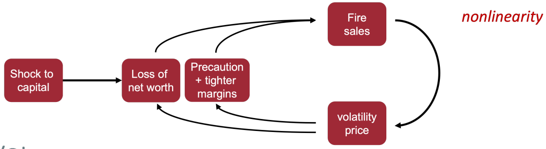
- Risk premia $=$ price of risk * (endogenous $+$ exogenous risk)
  - Exogenous risk – shock from outside
  - Endogenous risk
    - Amplification: adverse feedback loops
    - Multiple equilibria: Run, Sudden Stops
- Non-linearities are key for financial stability
  - Around vs. away from steady state

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

preventive

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



crisis management

3. Persistence/Slow recovery

Macro: Consumer vs. Finance Focused

- Consumption decision
  - Demand management at ZLB (liquidity trap) [interest rate drives c]
  - 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)

    runs, sudden stops, spirals

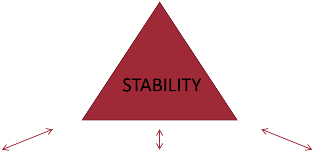
    - $\Delta\text{price} = f(\Delta\mathbb{E}[\text{future cash flows}, \Delta\text{risk premia}])$

  - Heterogeneity: wealth distribution across investors (+ consumers)

Cts.-time Macro: Macro-Finance vs HANK

Agents	**Heterogenous investor focus** - Net worth distribution (often discrete)	**Heterogenous consumer focus** - Net worth distribution (often cts.)
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	Price stickiness
Risk	Risk and Financial Frictions	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
- Financial stability
  Macroprudential policy
- Fiscal debt sustainability
  Fiscalpolicy

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

inter-action

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

inter-action

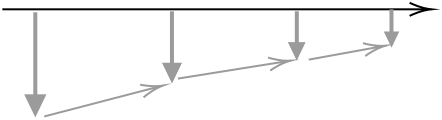
- Taxes/subsidies

Overview

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

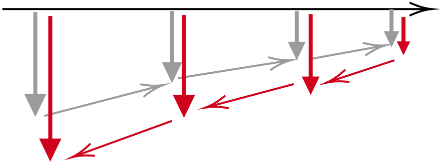
Persistence and Resilience

- 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

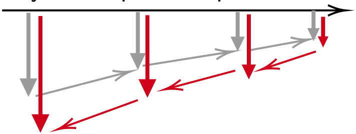


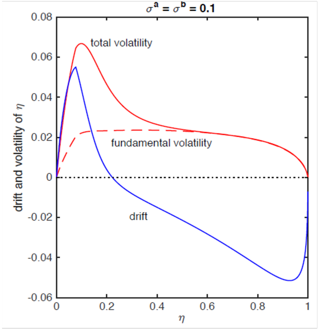
“Single Shock Critique”

- 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

$\Rightarrow$ Precautionary savings

  - Role for money/safe asset

$\Rightarrow$ Nonlinearities in crisis $\Rightarrow$ endogenous fait tails, skewness

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

Fan Charts & Endogenous Volatility Dynamics

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Overview

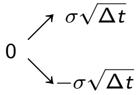
- Defining Macro-Finance
- Amplification, Persistence, Resilience
- Continuous Time Modeling

Why Continuous Time Modeling?

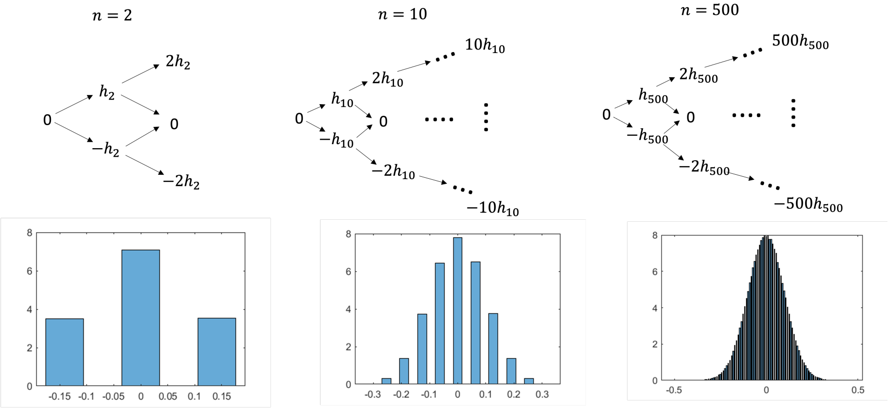
- Time aggregation
  - Data come in different frequency
    - GDP quarterly
    - High frequency financial data
- Consumption
  - Same IES within and across periods
  - Discrete time consumption
    - IES/RA within period $= \infty$, but across periods $= 1/\gamma$
- Optimal Stopping problems - no interger 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 $\mathrm{d}Z$

- Brownian Motion as a binomial tree over Δt.



- More steps with shrinking step size: $h_n = \sigma\sqrt{\Delta t/n}$

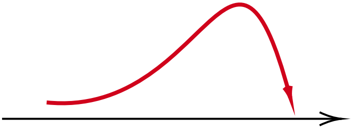


Itô Processes: Characterization, Skewness over Δt

- Itô processes ... fully characterized by drift and volatility

$$\mathrm{d}X_t = \mu(X_t, t)\mathrm{d}t + \sigma(X_t, t)\mathrm{d}Z_t$$

  - Arithmetic Itô's Process: $\mathrm{d}X_t = \mu_{X,t}\mathrm{d}t + \sigma_{X,t}\mathrm{d}Z_t$
  - Geometric Itô's Process: $\mathrm{d}X_t = \mu_t^X X_t\mathrm{d}t + \sigma_t^X X_t\mathrm{d}Z_t$
- Characterization for full volatility dynamics on Prob.-space
  - Discrete time: Probability loading on states
    conditional expectations $\mathbb{E}[X|Y]$ difficult to handle
  - Cts. time Loading on a Brownian Motion $\mathrm{d}Z_t$ captured by σ
- Normal distribution for dt, yet with skewed distribution for $\Delta t > 0$



  - If σ_t is time-varying
  - E.g. from normal-dt to log-normal-Δt and vice versa (geometric $\mathrm{d}X_t$.)

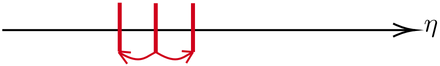
Continuity of Itô Processes

- 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: $b_t R_{t,t+1} \leqslant \min\{q_{t+1}\} k_t$
    - Cts. time: $b_t \leqslant (p_t + \underbrace{\mathrm{d}p_t}_{\to 0})k_t$

      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

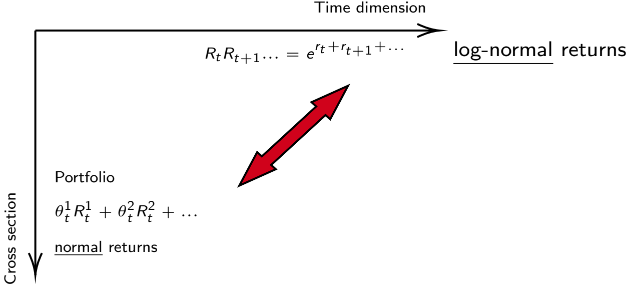
- in discrete time: e.g. $\mathbb{E}_t[V(\eta)]$
  - Need function $V(\eta)$ across all states η
  - Simulate η to obtain probability weights for η all realizations
- in continuous time with Itô: $\boxed{\mathbb{E}[dV(\eta)] = V'(\eta)\mu_\eta \mathrm{d}t + \frac{1}{2}V''(\eta)\sigma_\eta^2 dt}$
  - Just need the two neighboring grid points instead of the whole function $\rightarrow V''(\eta)$



  - $V'(\eta)$ is approximated by $\frac{V(\eta+\Delta)-V(\eta)}{\Delta}$ or $\frac{V(\eta)-V(\eta-\Delta)}{\Delta}$;
    $V''(\eta)$ by $\frac{V(\eta+\Delta)-V(\eta)-(V(\eta)-V(\eta-\Delta))}{\Delta^2}$
  - 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 η in discrete time.

Dynamic Portfolio Choice in Continuous Time

- Portfolio choice - tension in discrete time



  - Linearize — kills σ-term, all assets are equivalent
  - 2nd order approximation — kills time-varying σ
  - 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