Agent Based modelling of Housing Asset Bubble: a habit or subsistence utility function based investigation

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Introduction

- The world at large was at a loss to explain the magnitude as well as nature of calamity that hit the US market in 2007
- At the heart – Housing Asset Bubble
- Many theoretical and empirical works have come out
- Our wok tries to define a layered approach with *bounded rational* agents

Bounded Rationality

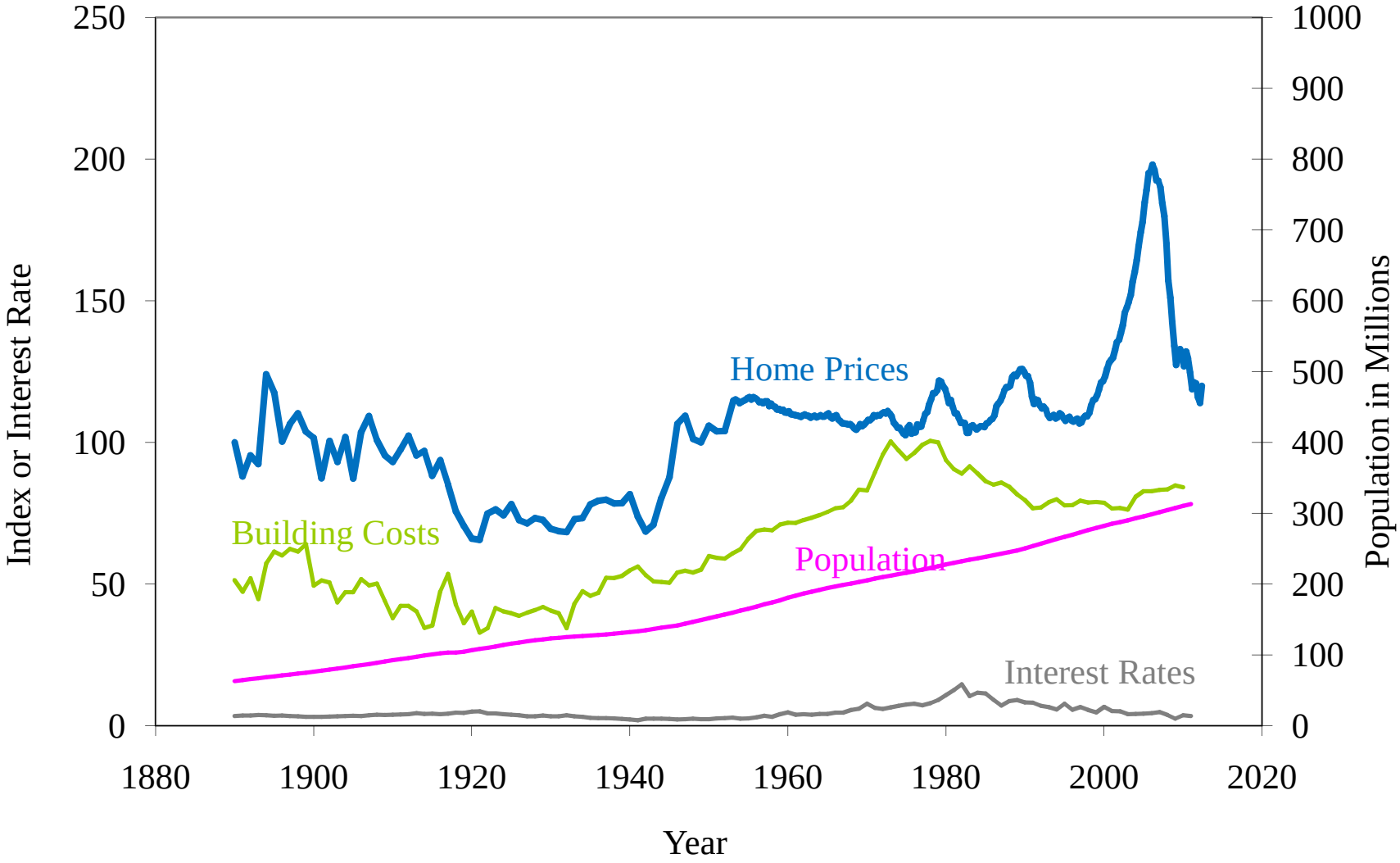
- Decisions of a complete irrational agent is hard to model
- There are two Avenues:
  - Mimic agents' collective behaviour to that of a physical process in a collective sense (PHYSICISTS-ROUTE)
  - Construct a departure from rationality (ECONOMISTS'ROUTE)

Why agent based models

- As Farmer (2009) points out
  - both the 'econometric' as well as 'dynamic stochastic models‘ inadequate to map the dynamics of the crisis of this magnitude
  - better alternative - use of agent-based models

Irrational Exuberance

- Robert Shiller (2008), “The subprime solution”,
  - ascribe it to 'irrational exuberance‘
  - Information cascading
- Martin Hellwig (2008): Systemic risk in the financial sector: an analysis of the subprime-mortgage financial crisis,
  - caused by identifiably faulty decisions, but also by flaws in financial system architecture.



Data provided by Robert J. Shiller, Irrational Exuberance, 2nd. Edition, Princeton University Press, 2009, also Subprime Solution, 2008, as updated by author.

Literature Review – Economic analysis of Housing Asset bubble

- Rendall L. Wray (2007), “Lessons from Sub-prime Meltdown”, The levy economic institute of bard college.
  - uses Hyman P. Minsky’s approach to analyze the international financial crisis initiated by problems in the U.S. real estate market
  - the role played by each of the key players—including
    brokers, appraisers, borrowers, securitizers, insurers, and regulators—in creating the crisis

Literature Review – Economic analysis of Housing Asset bubble

- Allen C. Goodman and Thomas d. Thibodeau, “Where are the speculative bubbles in US housing markets?”, Journal of Housing Economics (2008)
  - explores how much of the recent appreciation in US house prices was attributable to the fundamental economic determinants of house prices
  - demand side: the rate of homeownership in the US increased from 66.8% in 1999 to 69% in the fourth quarter of 2005
  - the supply side: land prices and housing construction costs increased substantially in real terms over this period
  - Extreme speculative activity, so prominently publicized, was extraordinarily localized.

Literature Review – Economic analysis of Housing Asset bubble

- Coleman IV, Major, LaCour-Little, Michael and Vandell, Kerry D. (2008), “Subprime lending and the housing bubble: Tail wags dog?”, Journal of Housing Economics
  - Concludes that rather than causing the run-up in house prices, the subprime market may well have been a joint product, along with house price increases,(i.e., the ‘‘tail”) of the changing institutional, political, and regulatory environment characteristic of the period after late 2003

Literature Review – Economic analysis of Housing Asset bubble

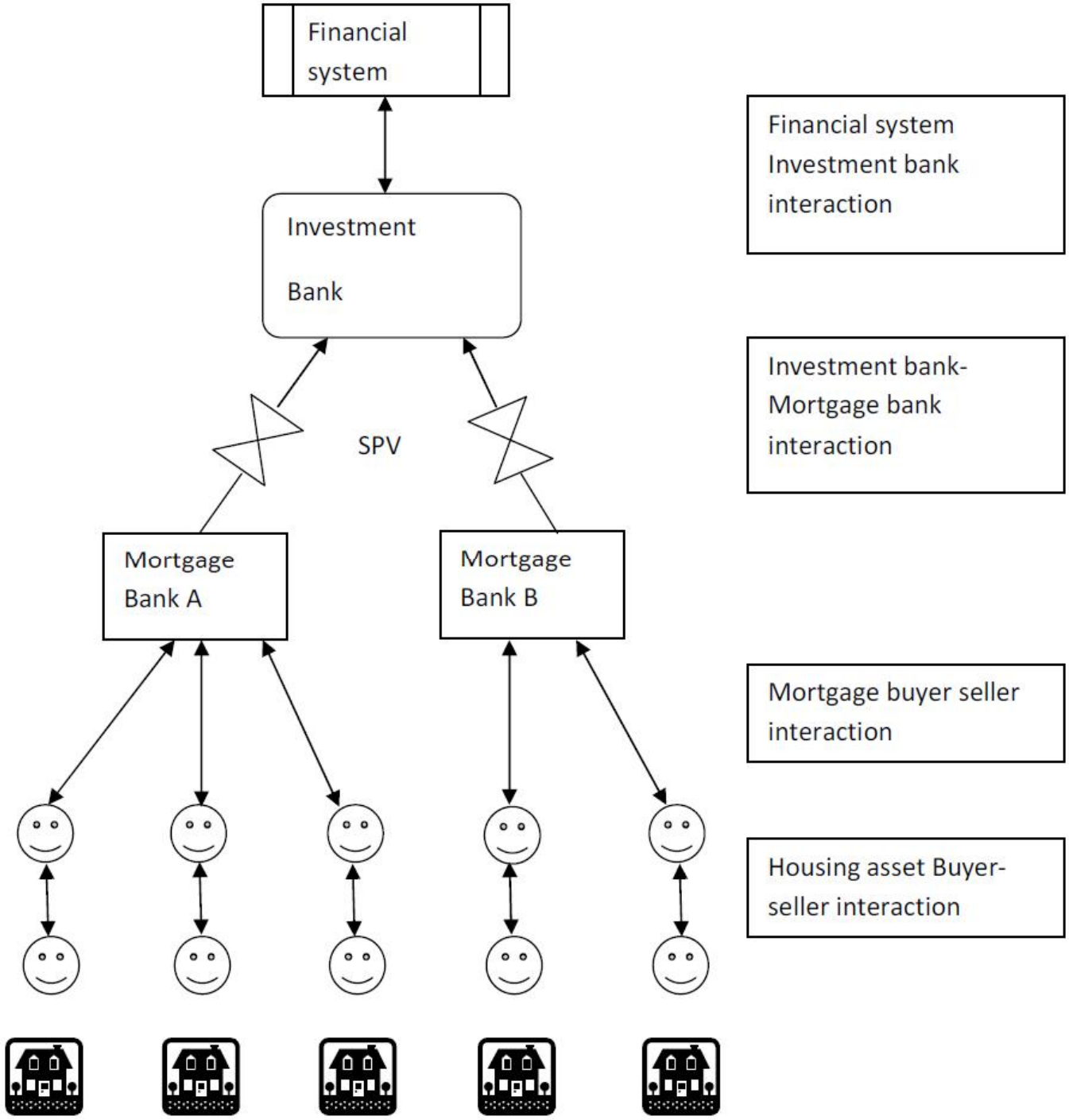
- Michel G. Crouhy, Robert A. Jarrow and Stuart M. Turnbull (2008), “The Subprime Credit Crisis of 07”.
- Francis A. Longstaff (2011), “The subprime credit crisis and contagion in financial markets?”, Journal of Financial Economics.
- Glaeser, Edward L., Gyourkob, Joseph and Saizb, Albert (2008), “Housing supply and housing bubbles”, Journal of Urban Economics.

Framework for analysis

- Our Modeling Assumption
  - to view the entire economic flow associated with the housing asset bubble as a multi-agent interaction process
  - model the system as a multi-agent dynamic interaction system
  - using agent-based simulation capture the dynamics of the failure

Our Grand Narrative

- Four tiers involving
  - the buyer seller interaction in the housing market at the lowest level
  - followed by the mortgage banks interaction with the borrowers.
  - At the upper level is the interaction of the large investment banks with the mortgage banks and the creation of Special Purpose Vehicles for asset securitization.
  - At the highest level is the interaction of the investment banks with the economic system.


Financial system
Investment Bank
SPV
Mortgage Bank A
Mortgage Bank B
Financial system Investment bank interaction
Investment bank-Mortgage bank interaction
Mortgage buyer seller interaction
Housing asset Buyer-seller interaction

The Model

- We model each household as a utility maximiser.

$$\text{Max } \Sigma_{t=0}^{\text{infinity}} \beta^t \, E \, u(c_t)$$

subject to a budget constraint

$$R_t \cdot a_t + y_t = c_t + a_{t+1}$$

Gross Return from Asset + Income = Consumption+ Saving

The Model

- She makes a decisions
  - Consumption-saving decision
- The housing asset's return differs from year to year

- Expectation of the agent is crucial in determining the investment in assets

Bellman Equation

- **Value Function** is valuation of an agent of a situation
- There are **state variables** that determine the state of an agent such as Asset Level of an agent from the past period
- There are **control variables** that is reflected in deciding the value of the current state
  - *A rational person chooses them to maximize value function*
  - *A bounded rational person may maximize based on mistaken perception*

Value Function

- $V(a) = \text{Max}_{c,\ a'}\ u(c) + \beta\ E\ V(a')$
- Subject to $c + a' = R \cdot a + y$

- $R' | R$ is a random variable.
  - An Autoregressive Process of Order 1.
  - Mean μ and standard deviation σ.

Euler Condition

- The optimization exercise relies on what is called the Euler Condition:

$$\mathbf{u'(c) = E}\ \beta\ \mathbf{R'\ u'(c')|R}$$

- Marginal utility of **consumption today** is equal to marginal utility of **consumption tomorrow** discounted suitably when today it is invested instead of being consumed.

Why not two assets in the model?

- Even if an Investor chooses between savings and Housing asset, the decision making process is not affected.

- Investor behaviour towards housing asset is independent of the other asset selection decision.

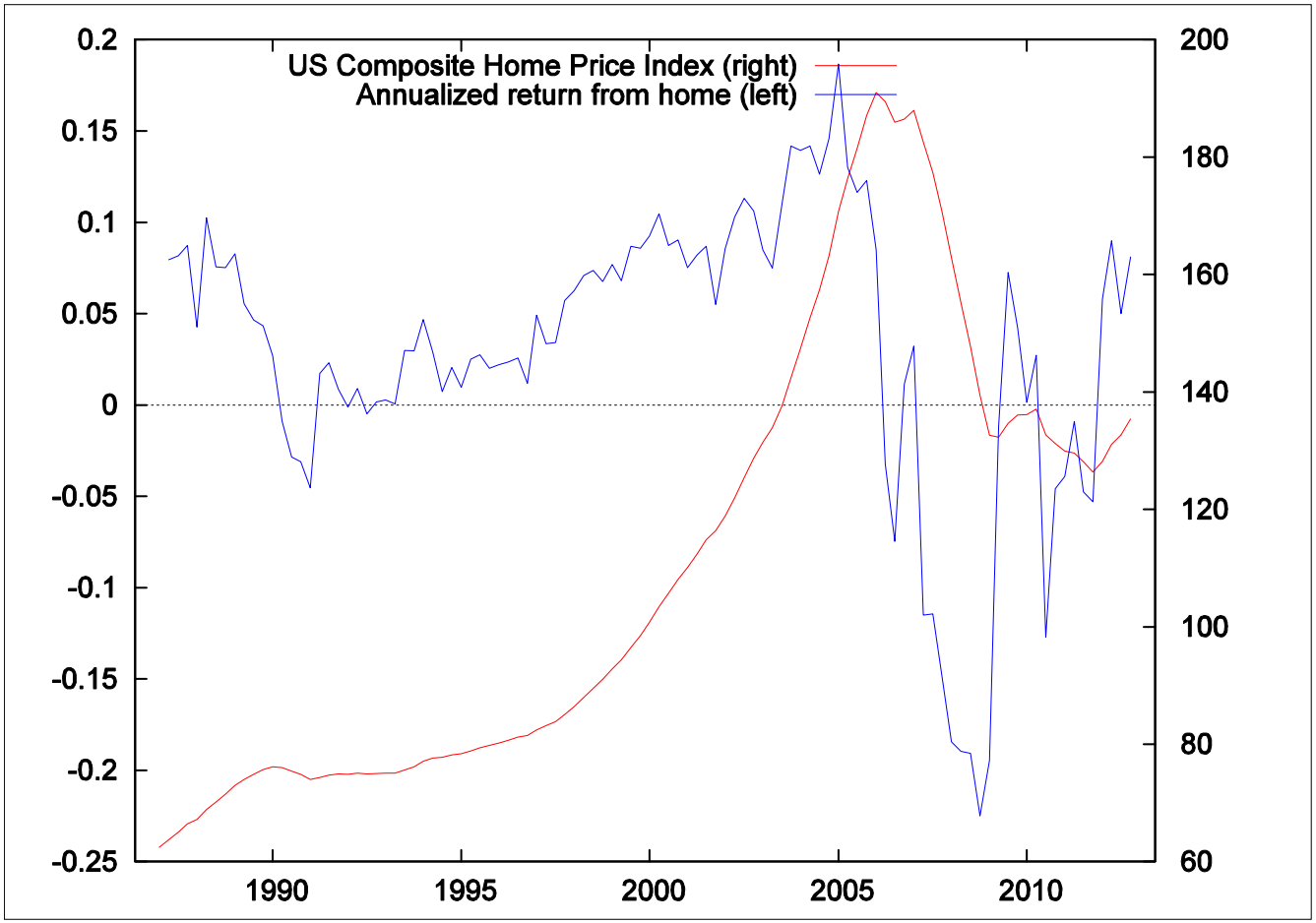
Specification and Calibration

- Utility function

$$u(c) = \begin{cases} \frac{c^{1-\frac{1}{\eta}}-1}{1-\frac{1}{\eta}} \text{ for } \eta \neq 1 \\ \log(c) \text{ for } \eta = 1 \end{cases}$$

- We assume that $\eta = 1$ (a benchmark in Macroeconomics)
- The other parameters that needs to be calibrated are those defining shock-distribution

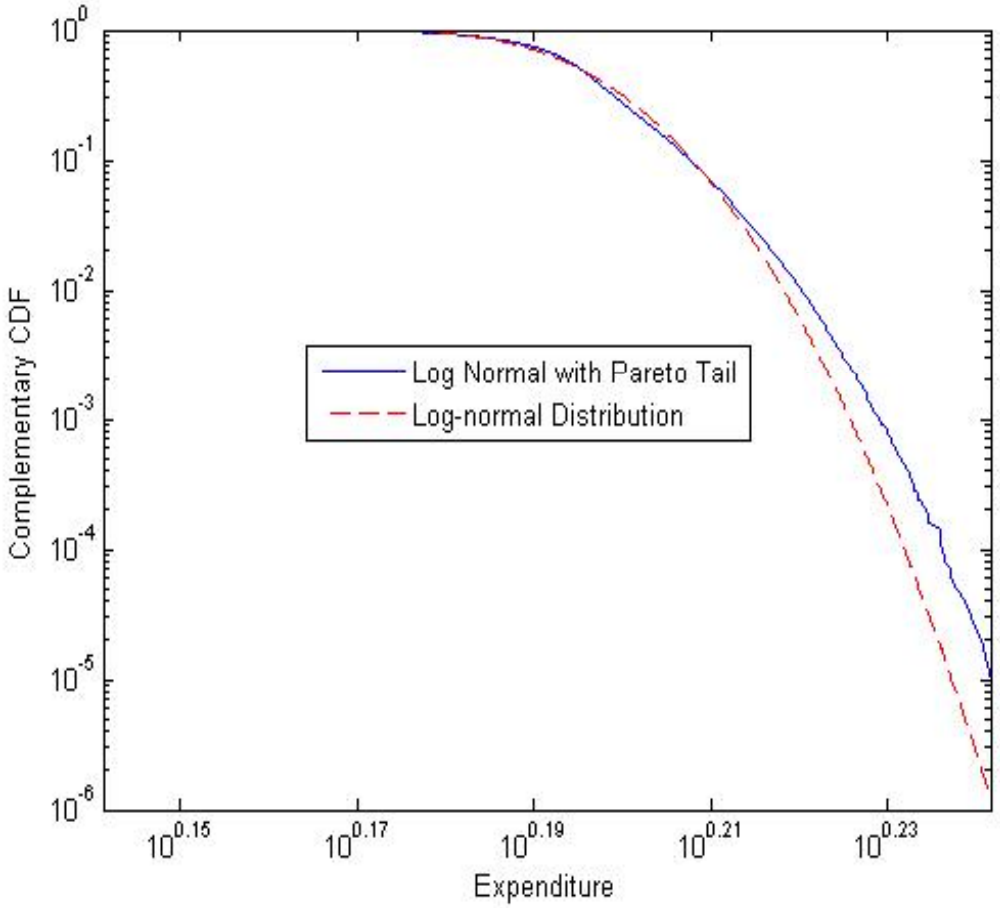
Calibration of Shocks



Mean Annualized Return = 3%; Standard Deviation = 0.08%; Autocorrelation Coefficient = +0.67

Wealth Distribution

Theory



Empirical Statistic

- Median Family Wealth = $120,000
- Median Family Income = $60,000
- 10% of the population has wealth in excess of $1.5 Million

We deduce the wealth distribution of students on the basis of this information.

Numerical Algorithm I

- Discretization of Shocks
  - Construction of a transition matrix
- Discretized Asset Level
- Initial Guess: The consumption of an agent is the minimum of value of income and existing asset value.
- Computation of Right Hand Side of the Euler equation

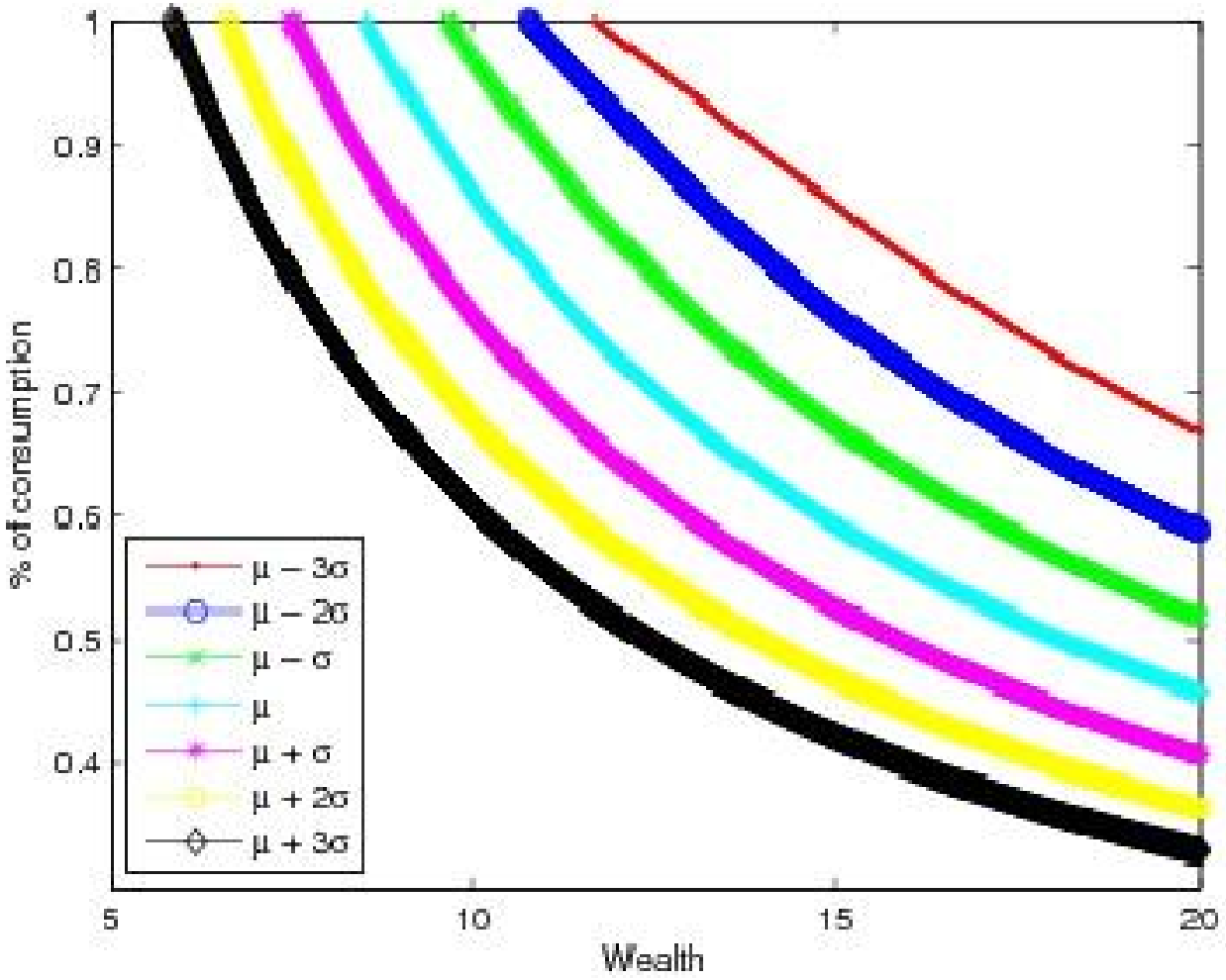
$$u'(c) = E\, \beta\, R'\, u'(c') | R$$

  - for a particular choice of consumption-savings
  - Using linear interpolation if necessary

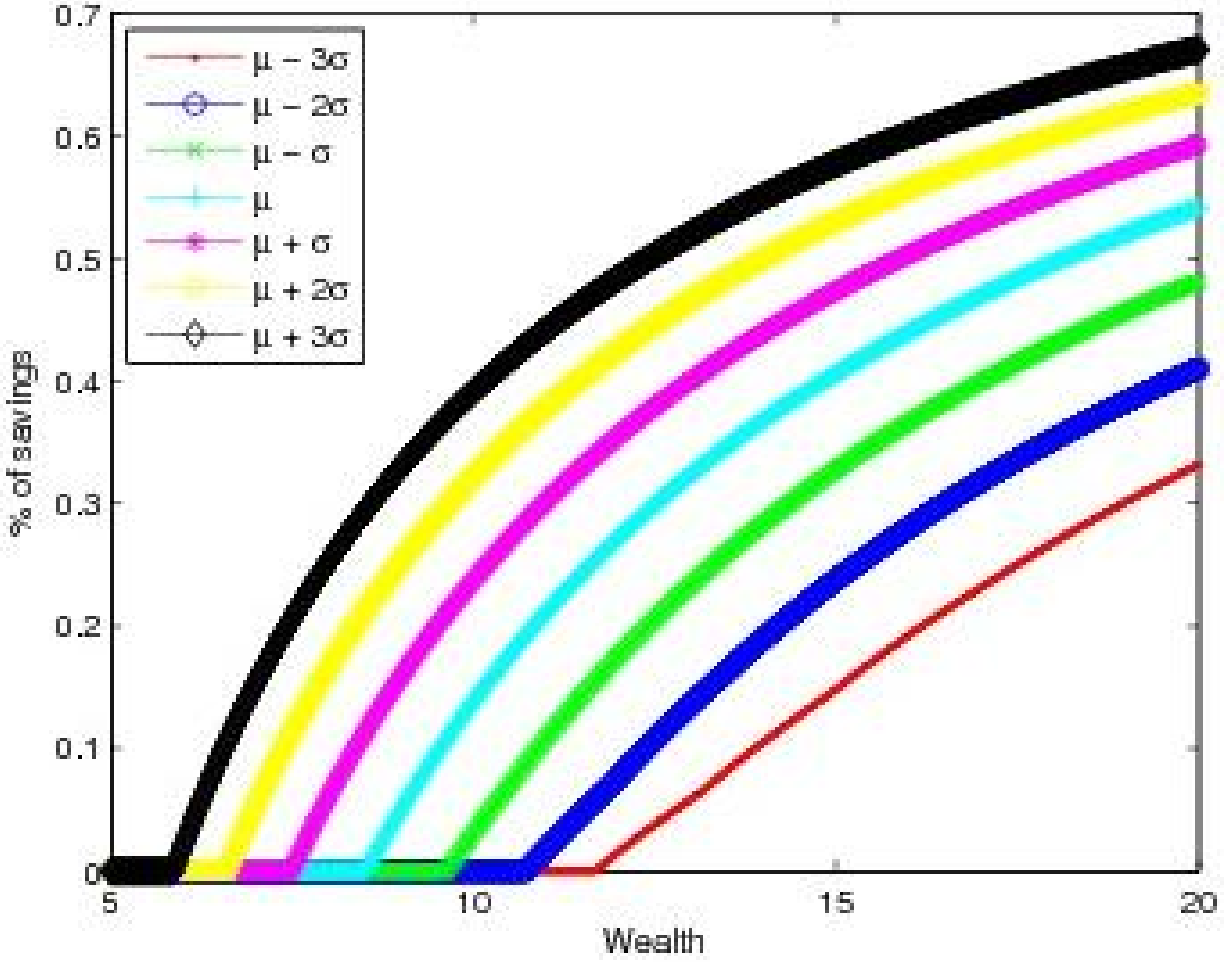
Numerical Algorithm II

- Left Hand Sides value can be computed for a particular choice.
- We solve for the right choice to equate LHS and RHS using Newton-Raphson method
- We update the optimal choice values for the discrete grid of asset levels.
- If the difference between previous values and updated values is sufficiently small (using $L^{Infinity}$ norm), we stop.
  - Otherwise, we carry on updating.

Consumption choice against wealth for various values of shocks



Savings choice against wealth for various values of shocks



Expectation holding the key to *Irrational Exuberance*

- There may not be any default with completely rational agents
- We need bounded rational agent who may form their expectation based on a rather *short memory*
- There will be discrepancy between agents' perception and the true expectation
- Our numerical experiments
  - **change the parameters of the return structure by 1%**
  - **Observe the *average* change in investment by agents**

Numerical Experiments:

Percentage Change in Investment for one percentage change in returns structure (Mean and Median)

Parameters	Value	Induced % change in investment
Mean Return	3.00%	10.6% and 1431%
S. D. of return	0.08%	0.08% and 3.4%
Autocorrelation Coefficient	0.67	0.07% and 5.0%

Caveat

- False Expectation is going to raise investment from the agents
- The supply of houses are fixed in the short term!
- The price of houses rises if demand increases.

Interaction of Agents

- If all agents are rational, there could be no crisis!
- A proportion of agents are move by bounded rationality.
  - A positive shock (windfall) moves their expectation
- They invest more in housing asset
  - A recursive circle

Questions to Ponder I

- When does an agent *default*?
  - There is only reduced consumption in the current model
  - For modeling default we need
  - *Either*, subsistence consumption
  - Or, habit based consumption model integrated in the framework

Questions to ponder II

- How is the price of a house determined?
  - There must be an exogenous interest to participate in the housing market apart from investment
  - The participation in the market also depends on the return as modeled

Towards a habit based model

- We need a utility function where habit the utility function is habit based in the sense that decreasing from last periods consumption is costly!
- Also default is costly for one will not be able to get loan if defaults.
- WORK-IN-PROGRESS