Research in Economics After the Crisis

John Geanakoplos

Tuesday 24 June 2014

Work extending:

Getting at Systemic Risk via an Agent-Based Model of the Housing Market

John Geanakoplos, Robert Axtell, Doyne Farmer, Peter Howitt

Benjamin Conlee
Jonathan Goldstein
Matthew Hendrey
Nathan M. Palmer
Chun-Yi Yang

Agent-Based Model

- 1.6 million households
- 1 million houses
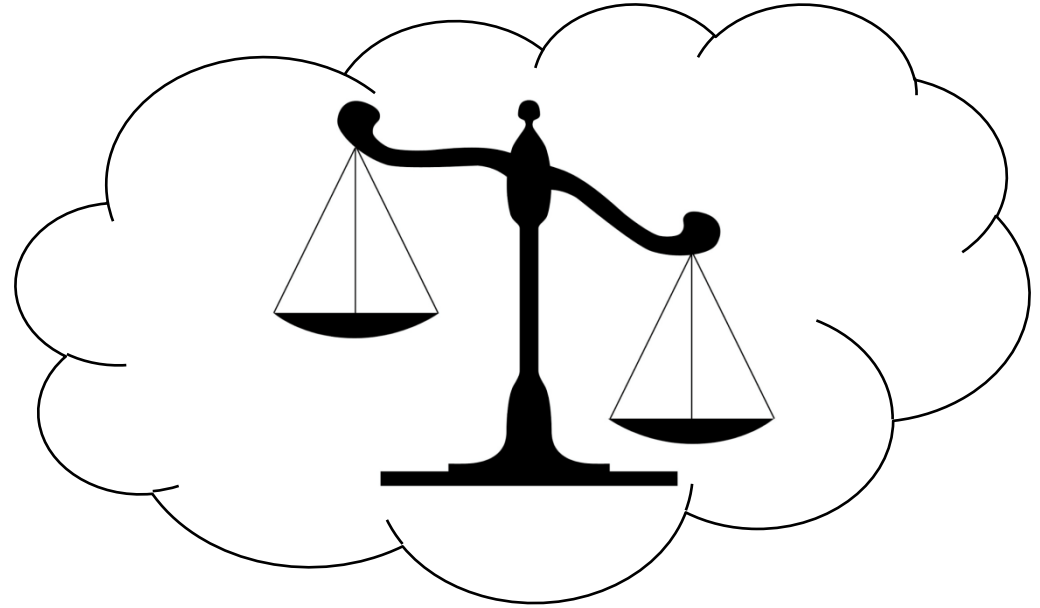- Unprecedented Scale

Key: Owner occupied 60%
Renter occupied 35%
Vacant 5%

3

Households

- Heterogeneous household-level characteristics: demographics, income, wealth, etc.

- Calibrated to actual micro data: ACS, Census, IRS, PSID

Behaviors

- Boundedly rational agents follow autonomous decision rules
- Heterogeneous behaviors and expectations forming, calibrated to micro data
- Distinct characteristics determine interactions in full-featured housing market

Selling a House

- Owners list houses with time-varying hazard
- Brokers mark up price from average of recent sales of comparable-quality units
- Distribution of house quality, listing probability, markup dynamics fit to historical MLS Data
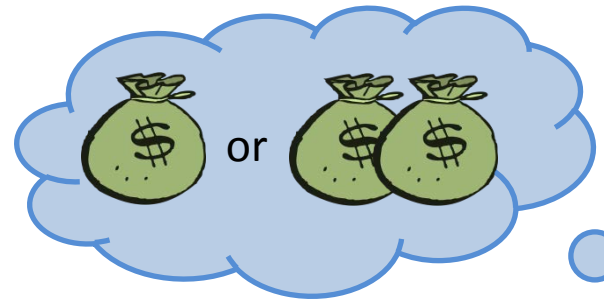
Buying a House

- Buyer faces upfront and continuing costs
- Upfront: down payment, paid out of pocket
- Continuing: mortgage, tax, maintenance, and related costs

Desired Expenditure

- Agents calibrate purchase price so monthly housing expenditures proportional to fraction of income

- Willing to pay greater fraction when expect future home price appreciation

- If buyer cannot afford down payment out of pocket, then cannot obtain loan
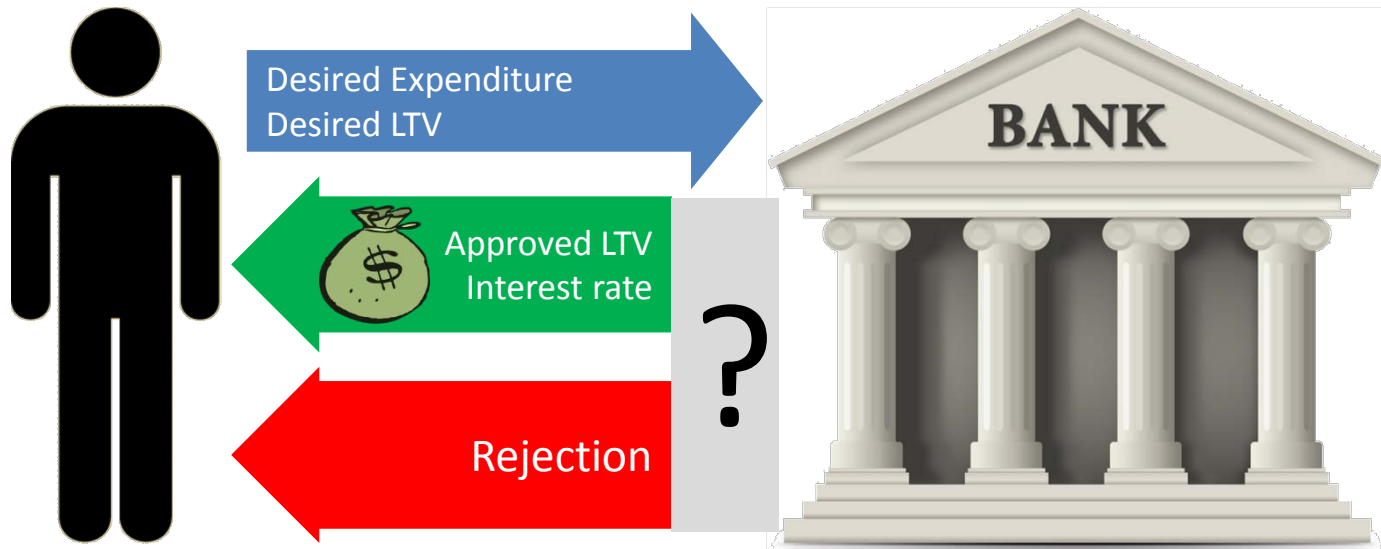
Desired Expenditure Formulation

$$P = \frac{\varepsilon \times h \times \text{Income}^g}{(\tau + c + \text{LTV} \times \text{Prime Rate} - a \times \text{Lagged HPA})}$$

where
- P is desired house price
- Income is contemporaneous annual household income
- LTV is average loan-to-value of loans issued in the prior 3 months
- Prime Rate is the contemporaneous Freddie Mac Primary Mortgage Market Survey average 30-year prime rate
- Lagged HPA is the statewide, lagged (past-year) appreciation in Case-Shiller Home Price Index
- We estimate $g = 0.56$, $h = 38.8$, $a = 0.16$ where g captures the amount of income spent on housing, h is a scaling factor, and a controls the strength of the effect of HPA on expenditure
- ε is an additional heterogeneity term we estimate as $log\,\varepsilon \sim N\,(-0.13, 0.46^2)$
- τ is contemporaneous annual percent tax, insurance, and HOA fees
- c is contemporaneous annual percent maintenance costs

Getting a Loan

Desired Expenditure
Desired LTV

Approved LTV
Interest rate

?

Rejection

BANK

- Application that includes desired expenditure and desired LTV

- Bank enforces DTI and LTV constraints before approving a loan

- Distribution of loan type (Fixed, Adjustable, IO), origination characteristics, and credit constraints matched to historical origination data
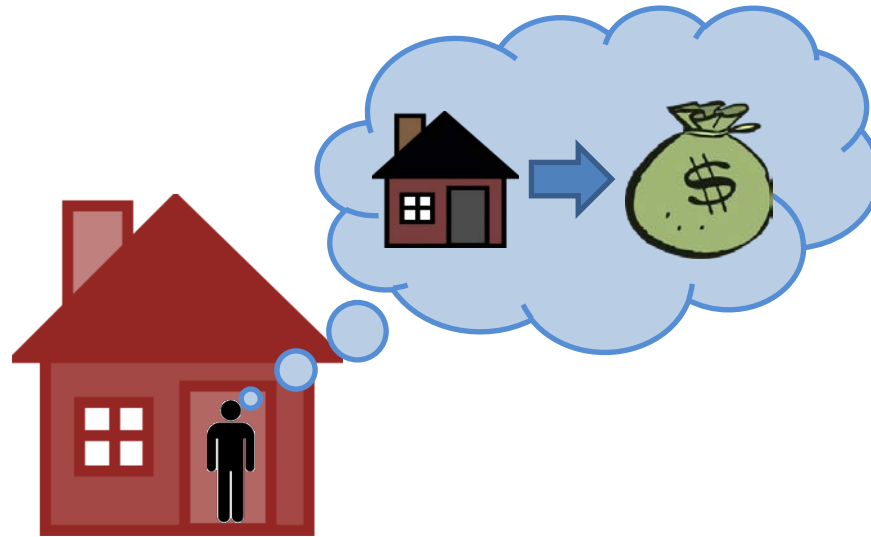
Housing Market: Matching
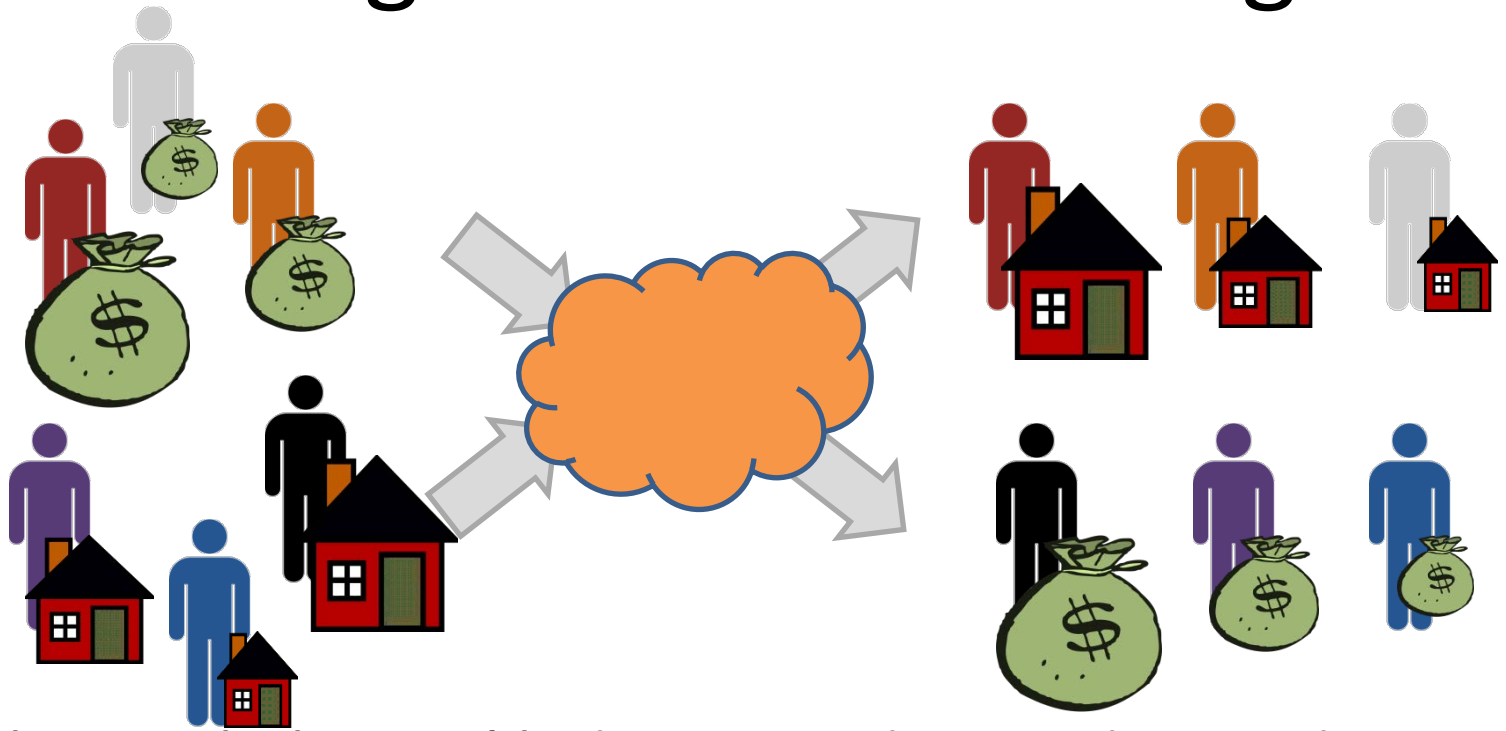
- Each month, buyers' bids received in random order
- Bid matched to highest-quality affordable house
- Unsold houses delisted or marked down by seller next period
- Delisting hazard and markdown dynamics calibrated to MLS Data

Investors

- Proportion of current homeowners consider buying investment properties if sufficient income

- Compute annual yield on a potential investment (property and mortgage terms) as expected rent and appreciation income less homeownership costs

- If purchase, set rent proportional to house quality and rental market tightness, calibrated to ACS data

Investor Yield Formulae

Yield computation:

$$\text{Yield} = \frac{r_t \cdot \text{Q} + a \cdot \%\Delta_{\text{HPI}} \cdot \text{HouseListPrice} - (c + \tau) \cdot \text{Q} \cdot \text{HPI} - \text{MortgagePayments}}{\text{Downpayment}}$$

where:
- r_t is rental rate for year t
- Q is House Quality
- a is the previously calibrated Desired Expenditure HPA effect
- $\%\Delta_{\text{HPI}}$ is 12 month percentage change of HPI
- c is contemporaneous annual percent maintenance costs
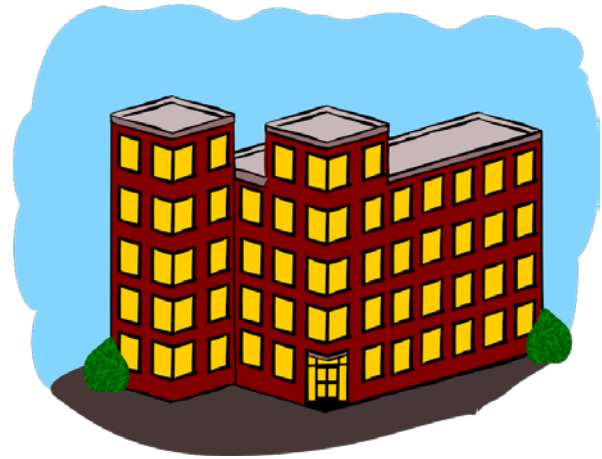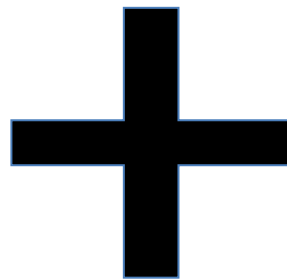- τ is contemporaneous annual percent tax, insurance, and HOA fee

Probability of buying house given annual yield: $\dfrac{1}{1 + e^{-(\text{Yield} \times p + q)}}$

where we estimate $p \approx 24.0$ and $q \approx -4.5$

Renters

- Households who are not approved for loans or cannot find houses may rent

- Rental unit stock: endogenous component from investors + exogenous stock of "apartments"

- Renters bid 30% of income on rent

Default

- Houses default strategically or when out of cash
- Probability of strategic default rises with CCLTV, declines in expected home price appreciation
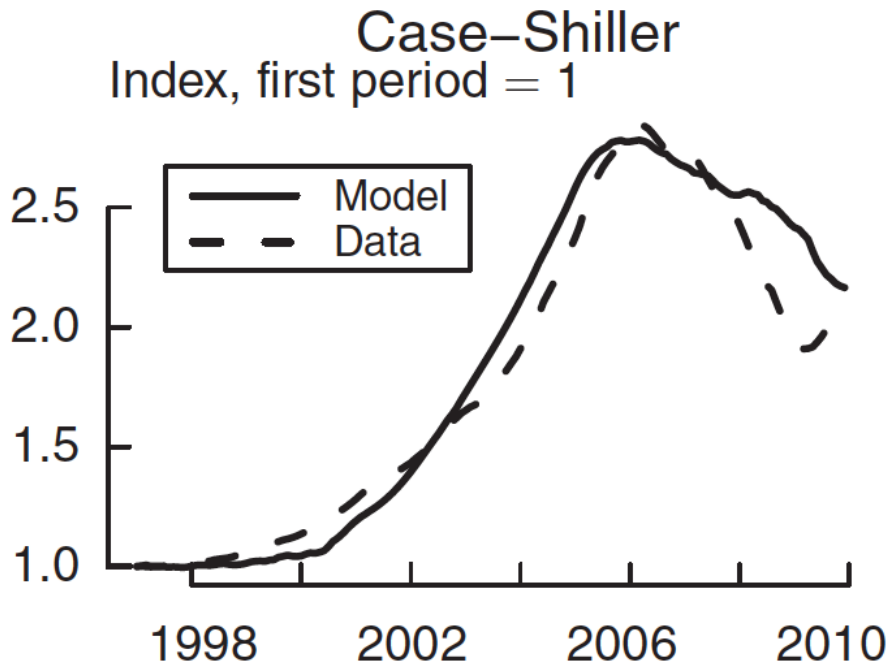- Calibrated to historical Loan Performance data.

Macro-Prudential Policy

- Full range of policy experiments
- Shocks to income, wealth, house stock
- Changes to interest / leverage sequences
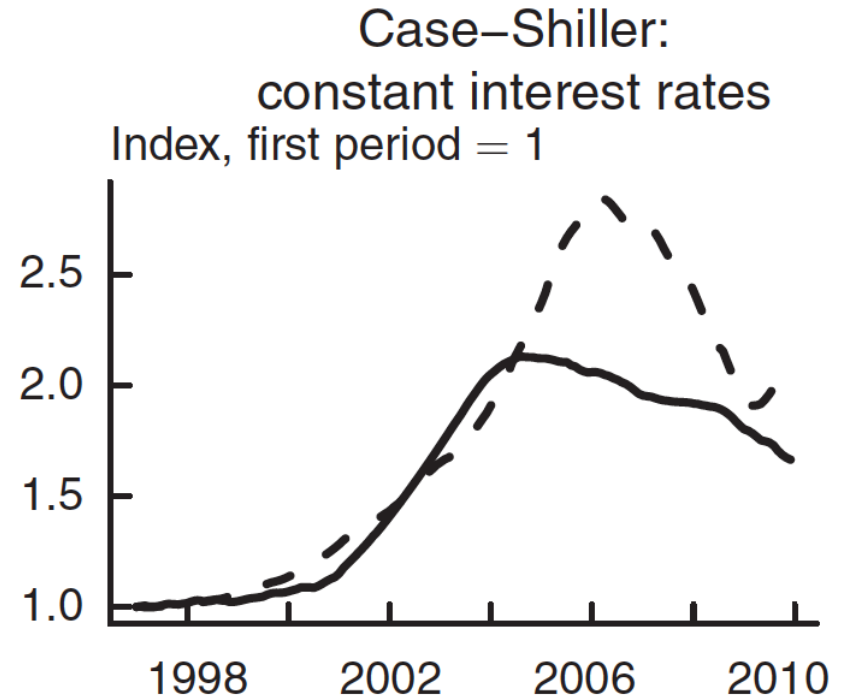- Government interventions and policy actions of arbitrary complexity

LEVERAGE

INTEREST RATE

?????
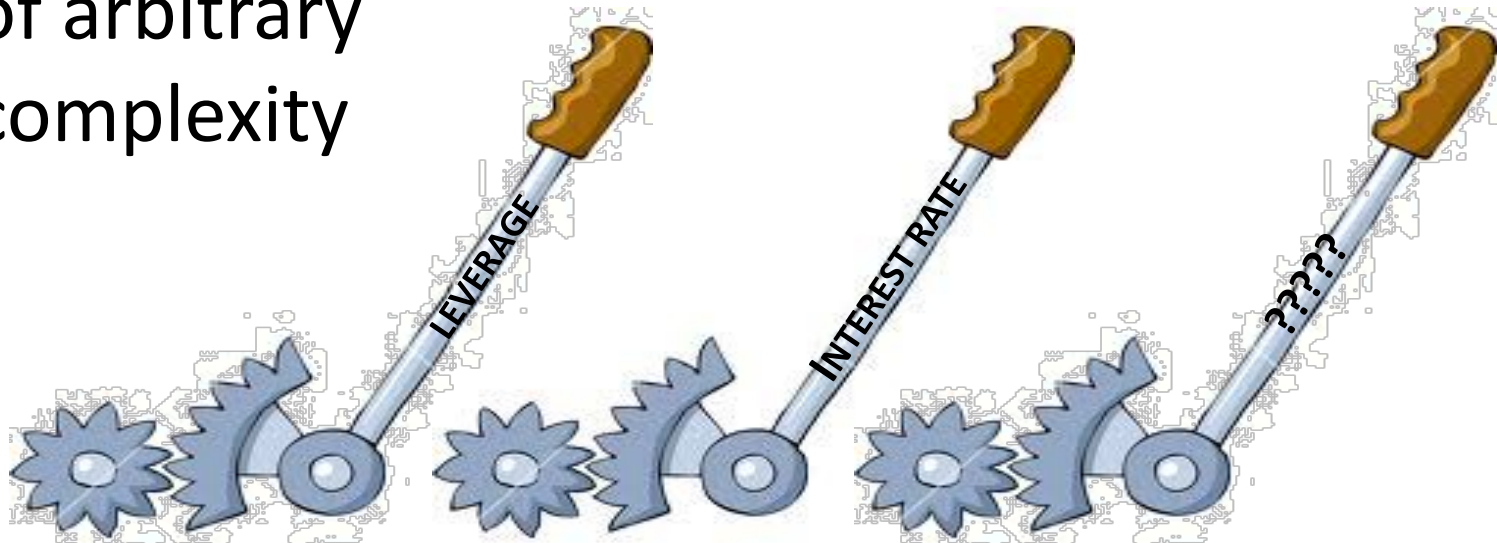
Effects of Interest Rates

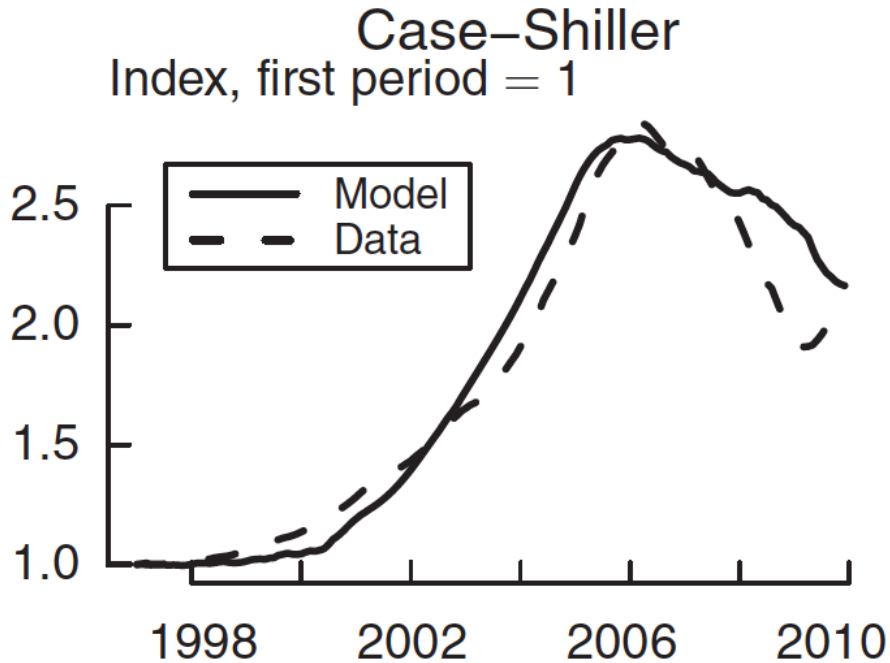**Case-Shiller in the baseline simulation**

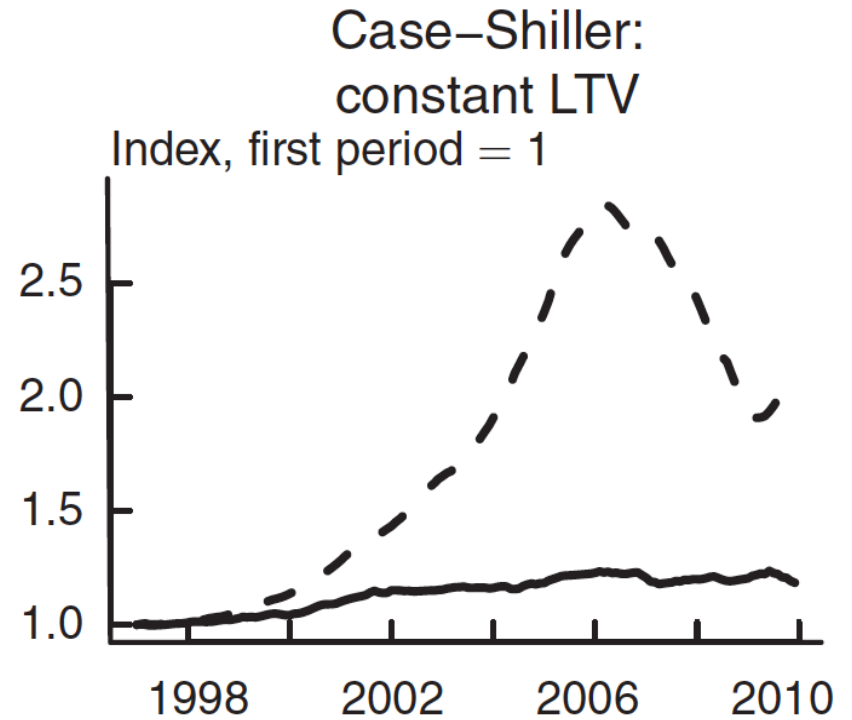**Case-Shiller with interest rates fixed at 1997 levels**

Effects of Leverage

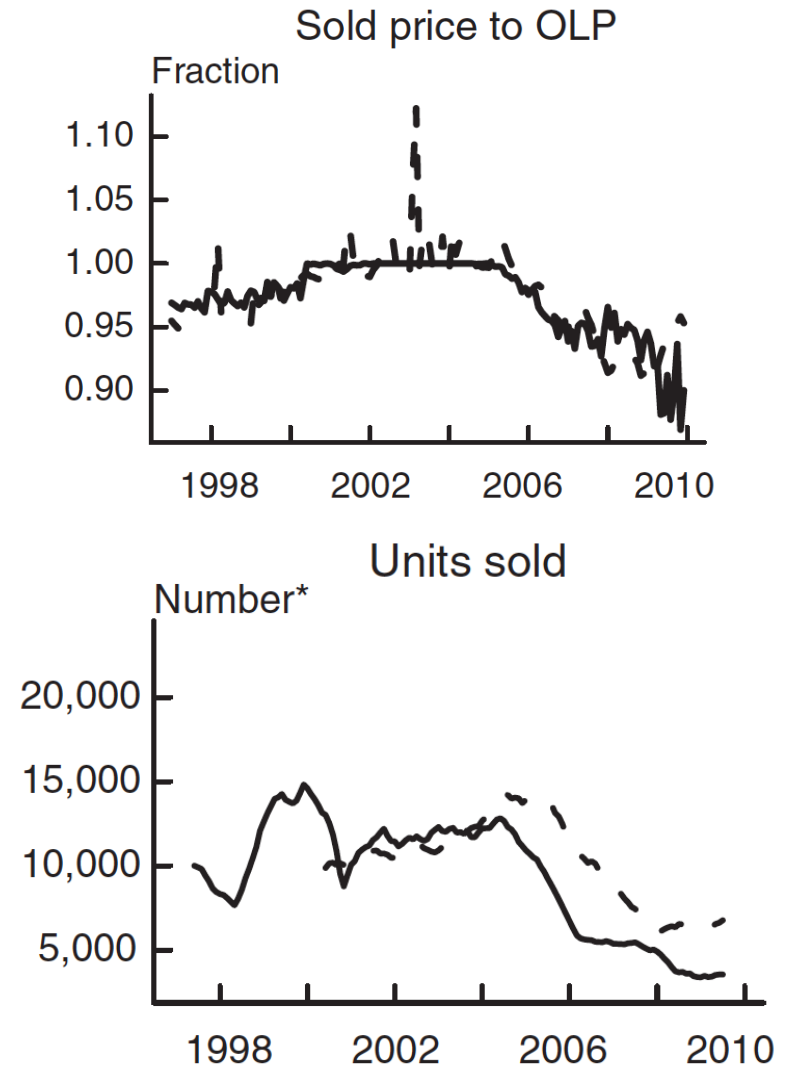**Case-Shiller in the baseline simulation**

Case-Shiller with LTV constraints fixed at 1997 levels

Evaluating Output

- Model designed to understand bubble, but endogenously generates other testable predictions

- Macro variables: ratio of sold price to original list price, Case-Shiller in quantiles of quality, avg sale price

- Housing stock: units sold, months of inventory, active listings, vacancy rate, time on market, homeownership rate

- Loans: loan applications, performing loans, defaults, foreclosures

Sold price to OLP

Fraction

1.10
1.05
1.00
0.95
0.90

1998   2002   2006   2010

Units sold

Number*

20,000
15,000
10,000
5,000

1998   2002   2006   2010

*Data is smoothed with centered 11–month moving average.

19

Conclusion

- Heterogeneity matters for economic modeling. Representative agent models were a necessary simplification in the pre-computer era. Computers are now powerful enough to model real-world complexity.

- Credit is multi-dimensional. Most borrowers do not borrow at the risk-free interest rate. Central banks should monitor the entire credit surface.