An Agent-Based Model of the Housing Market Bubble in Metropolitan Washington, D.C.

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Introduction

Central question: What was the relative importance of various factors in the boom and crash of the US housing market.

Preliminary conclusion: Low interest rates mattered; high leverage mattered more.

Agent Based Economics

The study of groups of interacting, boundedly rational agents

Agents are autonomous

The goal is to find patterns of collective behavior that emerge from decentralized interactions.

Examples range from abstract toy models to high fidelity empirical models

Why in this case?

- many aspects of the market to be accounted for
- heterogeneity and complexity of decisions
- rich data available
- has been useful on Wall Street

Methodology

Focus on household behavior, taking banking behavior, income, demographics as given

Calibrate the component modules independently and then put together without fitting to target data

Simulations are open-loop in house prices and wealth distribution

Initialization period of 100 years to get endogenous correlations

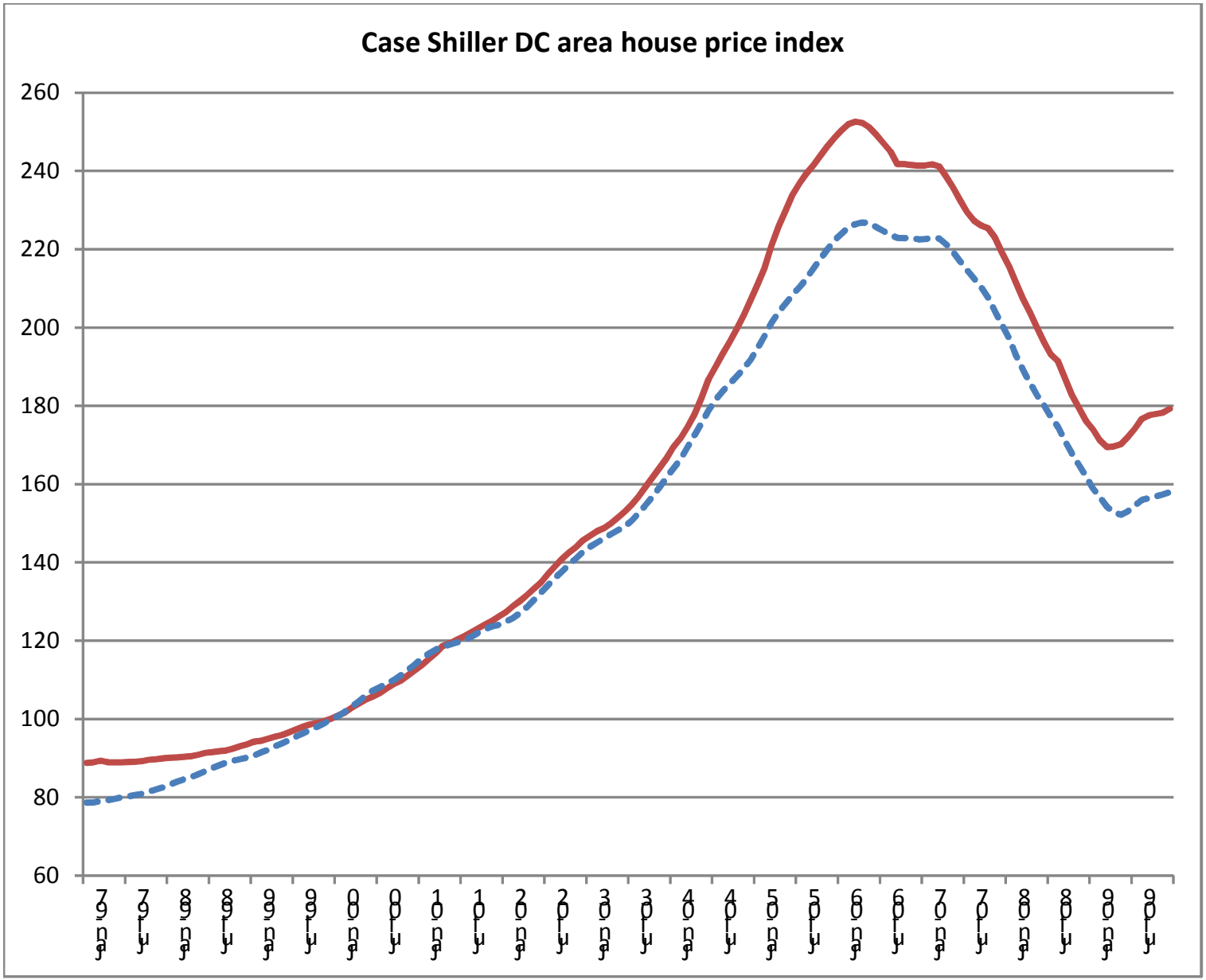
Data

Focus on Washington DC area, 1997-2009

Approximately 1.6 million households in 1997

DC area house prices

(National index in blue)



Data (cont'd)

Main Sources:

- Local
  - Core Logic - all public record data, over 3 million mortgages (including "hidden") and other housing variables
  - MLS (listings, price changes, delistings, sales)
  - IRS (income)
  - Loan Performance (more housing variables related to 885,000 of the mortgages)
  - Census Bureau (housing stock)
- National
  - PSID and CEX (national wealth, housing costs)
  - ACS (rental market, housing costs)

Outline of the model

Main objects

- Households (10:1 scale)
  - income, wealth, housing status, mortgage, initialized to data
- Houses of differing quality
  - qualities drawn from distribution of most recent sale prices relative to DC Case-Shiller
  - initial number of houses given by census data
- Mortgages of three kinds
  - interest only, ARM, conventional fixed
- Single bank
  - approves and makes mortgage loans
  - initiates foreclosure on all loans more than 2 months delinquent
  - attempts to sell foreclosed houses

Household actions

Each period (month) each household:

- receives income
- spends on non-housing consumption
- if holding a mortgage, decides whether to strategically default
- if holding a mortgage, decides whether to refinance
- pays housing cost (rental, or maintenance, tax, insurance and mortgage) if wealthy enough

Household actions (cont'd)

- decides whether to attempt buying a house
- if buying, chooses a desired expenditure and leverage
- if living in own house, possibly invests in a rental property
- if living in own house decides whether to list it and what price
- if already listing, decides whether to delist or reduce price
- if owning a vacant rental unit decides on rent

Household income

Carroll (BPEA, 1992) estimated the process from PSID data:

$$\ln Y = \ln Y_p + \ln Y_t$$

where:

$\ln Y_p$ is a random walk with drift (2% pa) and normal increments, and $\ln Y_t$ is the product of an iid normal variable and a (0,1) Bernoulli shock with $1 - p$ proportional to the unemployment rate

After this process determines the rank order of each household's income, the distribution is clamped to IRS data. (Each hh gets the actual income of its percentile.

Listing

The probability of listing is clamped to MLS data

The original list price determined by an equation estimated using the same data:

$$OLP = 0.99 \cdot \varepsilon \cdot \overline{P} \cdot e^{0.22 + 0.22 \ln s - 0.011 \ln DOM}$$

where:

OLP	original list price
$\overline{P}$	avg price of "comparable" houses recently sold
s	recent avg sold/OLP ratio
DOM	recent avg days on market
ε	non-Gaussian shock drawn from regression residuals

Delisting and Price Reductions

Delisting probability clamped to bin distribution conditional on days on market (MLS data)

Probability and size of price reduction drawn from binned distribution of markdowns depending on DOM and recent reductions

Desired Expenditure and Leverage

- Desired expenditure originally set to make housing cost equal one third of income, with individual shocks
- Now it is a concave function of Y:

$$P^* = \frac{\varepsilon h Y^g}{\tau + c + LTV \cdot i - a \cdot HPA}$$

τ	tax and insurance per dollar house price
c	maintenance per dollar house price
i	prime rate
HPA	last 12 months' avg % house price appreciation
ε	lognormal individual shock

(parameters $h, g, \tau, c, a, \sigma_\varepsilon$ estimated from PSID and ACS)

- Desired leverage drawn from bin distribution conditional on desired expenditure size using CoreLogic data.

Loan approval process

- Household must satisfy 3 constraints:
  1. LTV
  2. DTI
  3. Wealth
- Bank initially assigns a loan chosen randomly from empirical distribution of type, rate, LTV conditional on expenditure.
- If this doesn't fit, the loan size is adjusted to satisfy constraints.
- If the fit requires a loan greater than our "estimated" max LTV, or min DTI, no loan is approved

The matching process

- Approved buyers are then selected in random order and matched with the highest quality house on the market at no more than desired expenditure. (List price is the sale price.)

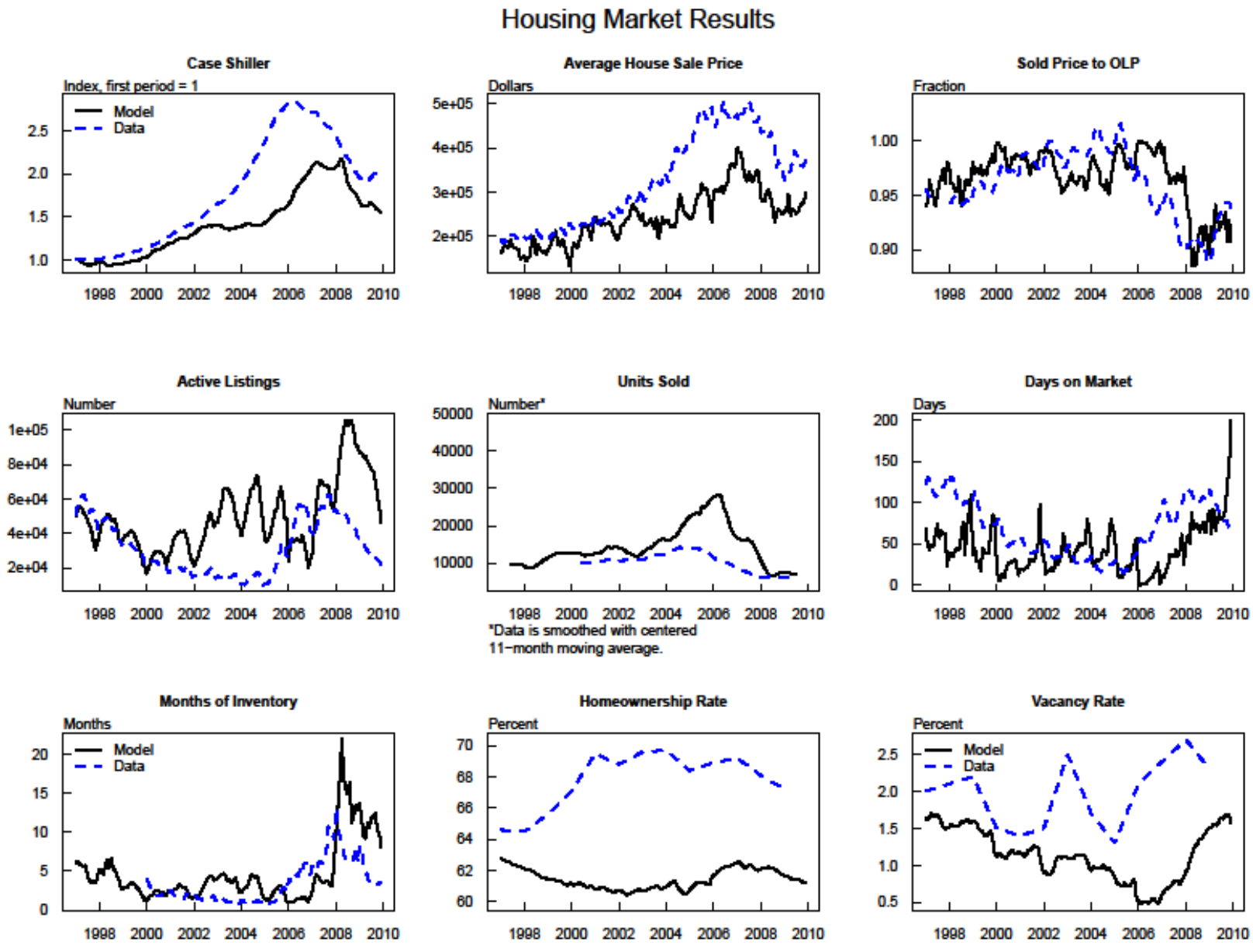
- Before agreeing, the buyer calculates the relative advantage of renting a unit of similar quality:

$$RA = P \cdot (\tau + c + LTV \cdot i - a \cdot HPA) - r$$

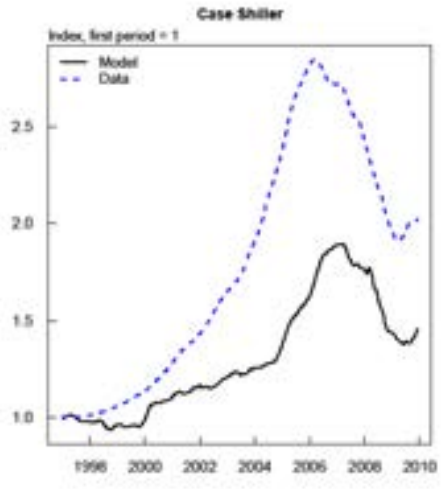
  and rents instead with probability fitted as logistic of RA

- Unsuccessful buyers always choose to rent

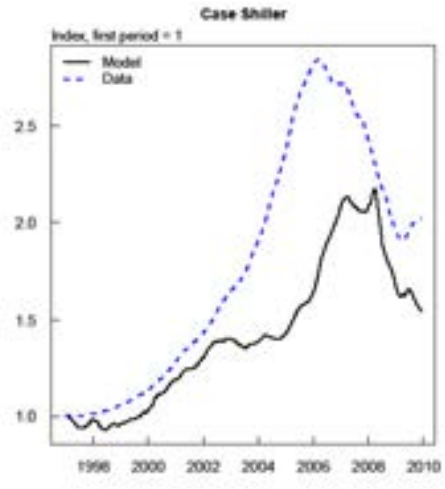
Baseline results



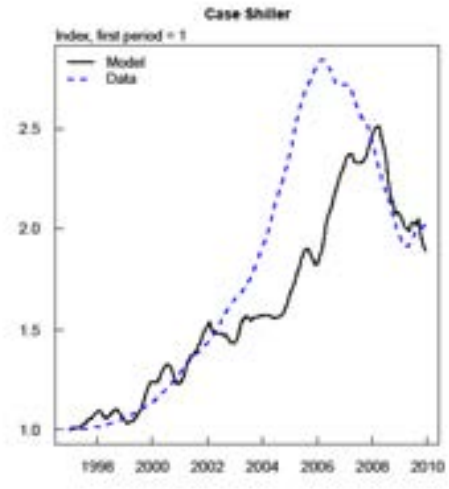
Sensitivity: The HPA effect



Case-Shiller, $a = 0.08$

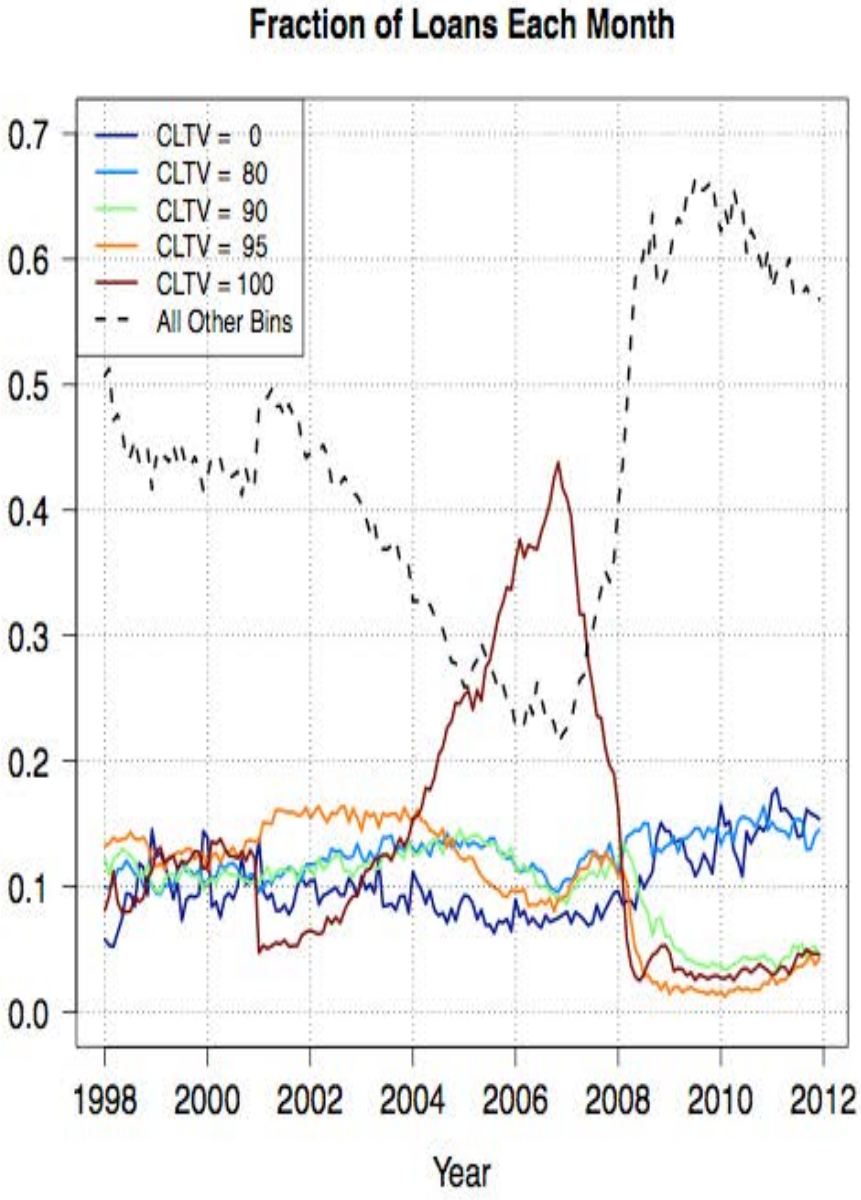


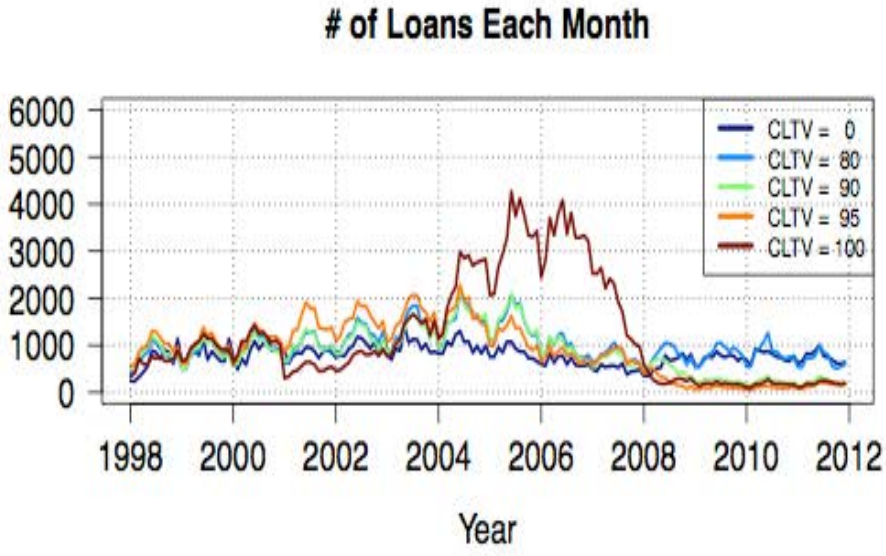
Case-Shiller, $a = 0.16$

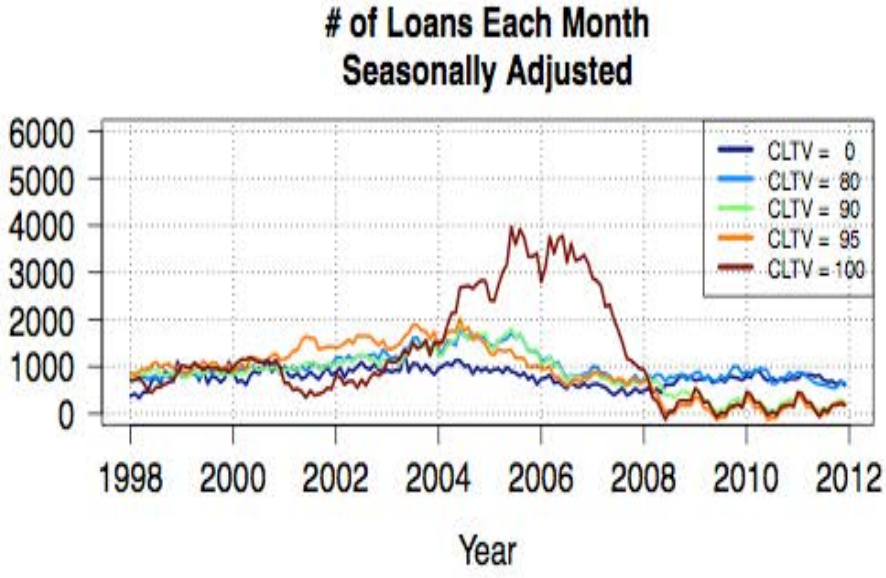


Case-Shiller, $a = 0.24$

Changing leverage constraints

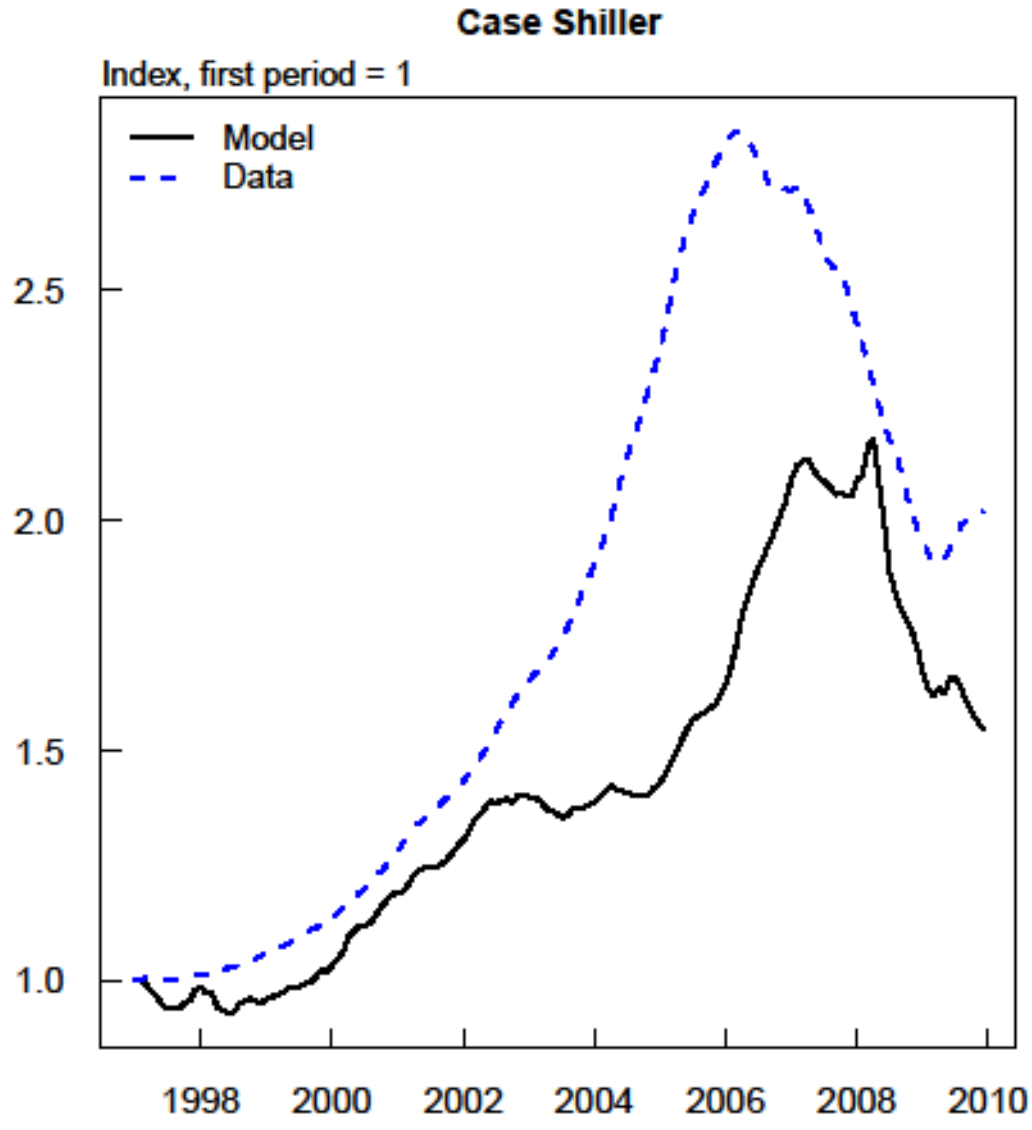






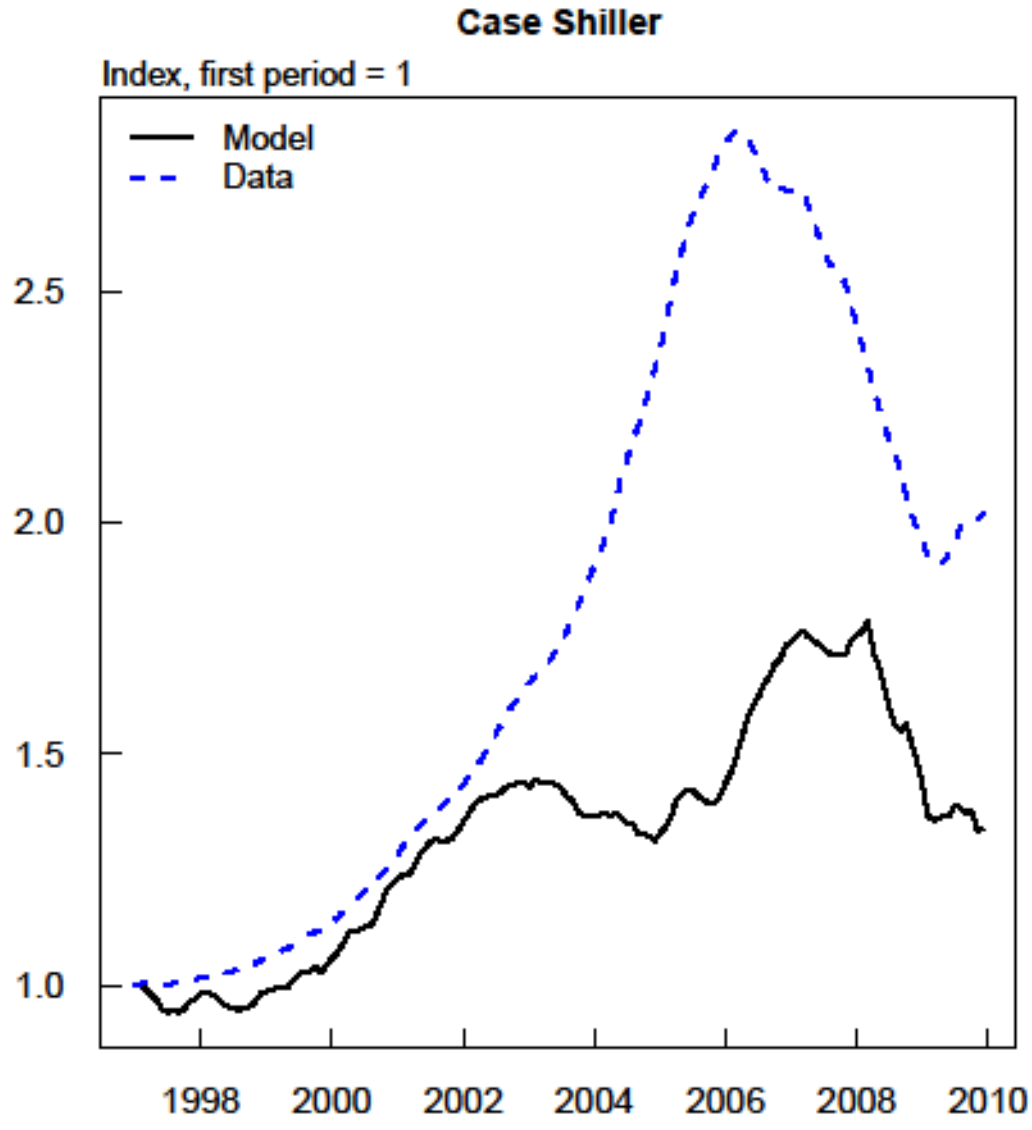
The effects of interest rates

Case-Shiller in the baseline simulation



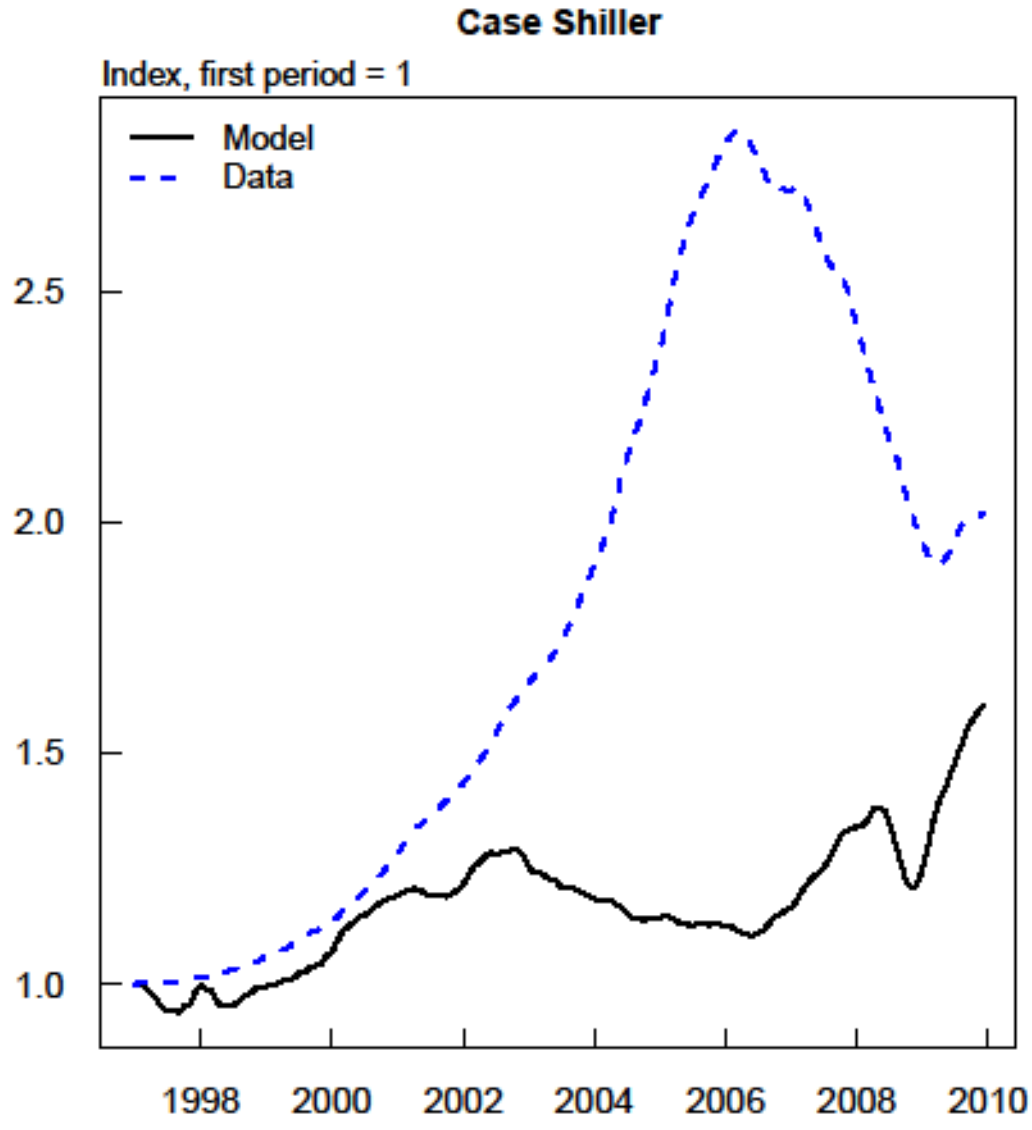
The effects of interest rates

Case-Shiller with interest rates fixed at 1997 levels



The effects of leverage

Case-Shiller with LTV constraints fixed at 1997 levels



The next steps

- Work on homeownership rates
- Validate model on other cities
- Aggregate across cities
- Incorporate into an agent-based macro model