Unemployment and the US Housing Market during the Great Recession

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AREUEA ASSA
January, 2020
Unemployment and Housing Market

sources: house price (Zillow), delinquencies (Fed), unemployment (Fed)
Why did house prices drop so much?

This paper

- quantitative lifecycle model of US housing market
- fit to Survey of Consumer Finances panel

Main results

- weak labor market explains 1/3 of house price decline
- tighter credit conditions account for 1/2
- Home Affordable Modification Program prevents extra 1/3 drop
Key new features

Income process matches consequences of job loss over business cycle

▶ large and long lasting effect on income
▶ worse in recessions
⇒ lower demand for housing in the bust
Key new features

Income process matches consequences of job loss over business cycle

- large and long lasting effect on income
- worse in recessions
⇒ lower demand for housing in the bust

Moving shocks: match survey evidence on reasons for moving

- housing market illiquid ⇒ price depends on who moves
- 1/2 movers report family, health, and other reasons
- movers are younger than average
  * less secure jobs ⇒ more sensitive to unemployment
  * lower income & wealth ⇒ more sensitive to credit
⇒ amplified effect of labor and credit market conditions
Model overview

Individual household problems

- lifecycle consumption-savings choice, rent vs own houses
  - face income and moving shocks
- borrow using credit cards, mortgages, home equity lines of credit
  - can default on any loan, prepay mortgage

Aggregate economy

- business cycle driven by 2-state Markov chain: boom and bust
  - bust: tighter credit, weaker labor mkt, lower expectations etc
- equilibrium house prices clear markets given observed supply
  - 2 endogenous prices: small & large houses
Moving shocks

▶ 1/2 moves arise endogenously as optimal choice
▶ 1/2 moves: idiosyncratic shocks, prob. depends on age

if shock hits, household has to move out
▶ homeowner sells house, renter leaves rental unit
▶ after that, can buy new house or rent

implications

1. ex post: young move more, so movers poor and lose jobs frequently
2. ex ante: moving risk affects decisions

1 + 2 ⇒ demand for housing more sensitive to aggregate conditions
Consequences of job loss

Micro empirical evidence

1. large and long lasting effect on income
   ▶ unemployment spell: time to find a job
   ▶ loss of job quality: next job pays less
   ▶ loss of job security: more likely to lose job again

2. worse in recessions

Model summary

1. Job ladder: better job quality and security at higher steps
2. Lower job finding rates in recessions
(log) Income = $W + \text{age profile} + \text{transitory shock}$

Higher steps = better jobs
- Quality: higher wage $W$
- Security: lower separation $s_i$

Transition
- Employed may climb up
- Unemployed may fall down
business cycle: two-state Markov chain (Boom, Bust)

parameters differ across states

1. labor: job finding rates
2. finance: interest rates, borrowing limits, mortgage amortization
3. housing: supply, transaction cost, house price expectations
4. mortgage subsidy is present only in Bust
Quantitative exercise overview

Exercise 2007: quantify & test model

- assign state: aggregate = boom, individual = SCF 2007
- estimate preference parameters to match aggregates in 2007
  - params: discount, housing services, util. costs of defaults and moving
  - targets: savings, house prices, aggregate delinquency and moving rates
- check untargeted moments: x-section of households’ choices by age

Exercise 2009: run experiments to study Bust

- assign state: aggregate = bust, individual = SCF 2009
- keep preference parameters fixed, no moments targeted
- result: match house price drop, mortgage & credit card delinquency.
- decomposition
## Results: Model vs Data

<table>
<thead>
<tr>
<th></th>
<th>Delinquency rate, %</th>
<th>Mean house price level 2007, drop later</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Credit card</td>
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</tr>
<tr>
<td>Model 2007</td>
<td>4.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Data 2007</td>
<td>4.0</td>
<td>2.7</td>
</tr>
<tr>
<td>Model 2009</td>
<td>7.2</td>
<td>7.5</td>
</tr>
<tr>
<td>Data 2009</td>
<td>6.8</td>
<td>8.6</td>
</tr>
<tr>
<td>Data 2012</td>
<td>2.9</td>
<td>10.4</td>
</tr>
</tbody>
</table>

- data on house prices: Zillow median home value, 2007 $k
- data on delinquencies: Federal Reserve
- last column: 2007 is price level, 2009 and below is % drop
## Results: decomposition

<table>
<thead>
<tr>
<th>In which order shock added</th>
<th>Added First</th>
<th>Added Last</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial mkt conditions</strong></td>
<td>17.8</td>
<td>20.8</td>
</tr>
<tr>
<td>Mortgage</td>
<td>11.9</td>
<td>17.5</td>
</tr>
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<td>HELOC</td>
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<tr>
<td>House price growth expectations</td>
<td>2.9</td>
<td>6.1</td>
</tr>
<tr>
<td>Housing transaction cost</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Balance sheet</td>
<td>-0.9</td>
<td>2.0</td>
</tr>
<tr>
<td>Mortgage subsidy</td>
<td>-10.0</td>
<td>-8.9</td>
</tr>
<tr>
<td><strong>All together</strong></td>
<td>25</td>
<td>25</td>
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*Added First:* fall in average house price when only one shock in action  
*Added Last:* rise in house price if the shock removed  
All numbers in % of average price in 2007
### Results: subsidy, moving shock

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**No moving shock**

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Moving rates with and without shocks, %

- **data**
- **baseline**
- **no moving shock**

intro
Conclusion

- Conditions in which HH live changed a lot during crisis
- Can these changes explain the large decline in house prices?
  - Yes, but need moving shocks & rich enough income process
- Which of these conditions matter more for house prices?
  - Tighter credit constraints on mortgages = 1/2 of bust
  - Low job finding rates = 1/3
  - Expectations = 1/6
- What is the direct effect of HAMP subsidy on house prices?
  - Prevents 10% extra decline = 1/3 of bust
Appendix
Why did house prices drop so much?

This paper

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- fit to Survey of Consumer Finances panel

Main new features

- income process matches consequences of job loss over business cycle
  ⇒ unemployment rate is signal of future income
- moving shocks match survey evidence on reasons for moving
  ⇒ more young movers, who are poor and lose jobs more frequently

Main results

- weak labor market explains 1/3 of house price decline
- tighter credit conditions account for 1/2
- Home Affordable Modification Program prevents extra 1/3 drop
Recent literature

Quantitative models of housing bust: *various forces*

- Garriga and Hedlund (2016): *downpayment constraints, income*
- Greenwald (2016): *payment-to-income constraints*
- Branch, Petrosky-Nadeau, Rochetau (2016): *home equity lines of credit*
- Kaplan, Mitman, Violante (2017): *house price expectations*
- This paper
  - one more force: *unemployment as signal of future income*
  - moving shocks change effects of all forces

Housing policy in Great Recession

- Eberly and Krishnamurthy (2014), Mitman (2016)

Unemployment and income dynamics

Preferences and housing

- life cycle with $L$ work years, $R$ retirement years

\[
\mathbb{E} \sum_{t=\text{age}}^{L+R} \beta^{t-\text{age}} \frac{U_t^{1-\gamma} - 1}{1-\gamma}
\]

(1)

\[
U_t = C_t^{1-\alpha} H_t^\alpha
\]

(2)

- three types of houses $H_t \in 1, H_1, H_2$
  - can rent $H_t = 1$ or own $H_t \in H_1, H_2$
  - utility cost of moving: $U_t^{\text{move}} = (1 - \tau_{\text{move}})U_t$

(details)
Balance sheet

Assets

- deposits
  risk free rate $r_d$
- houses
  capital gains (risky)
  utility & collateral
  maint. cost & prop. tax
  transaction cost if sell

Liabilities

- credit card
  $r_c > r_d$, limit as % of income
- mortgage \footnote{details}
  $r_c > r_m > r_d$
  LTV & PTI limits at origination
- home equity line of credit (heloc)
  $r_c > r_h > r_d$
  LTV limit every year

\footnote{budget constraints}
Mortgage policy

subsidy as fraction of annual payment

eligibility requirements

1. payment to income ratio not too low and not too high
2. income: in Low or Med group

information: only share $\omega$ informed and can apply if eligible

mechanism

1. direct: for subsidized hh
   - easier to afford pmt $\Rightarrow$ distress sale less likely
   - lower PV of pmts $\Rightarrow$ strategic default less likely
2. indirect: other hh realize they may be eligible later
   - similar effects, weaker effect per hh, but more hh here

result: default or distress sale less likely for all informed hh
Housing supply and equilibrium

Supply of rental apartments elastic at rate $p$
Supply of houses inelastic, differs between boom and bust

Equilibrium is the distribution of household choices together with prices $P_1$ and $P_2$ for Boom and Bust such that

1. each household solves its dynamic optimization problem
2. housing markets for $H_1$ and $H_2$ clear
Model fit by age

Non-Housing Networth (B), 2007$k

Mortgage (D), 2007$k

Homeownership, %

Moving Rate, annualized %

Total Networth Data, 2007$k

Total Networth Model, 2007$k
Consequences of job loss

Micro empirical evidence

1. large and long lasting effect on income
   ▶ unemployment spell: time to find a job
   ▶ loss of job quality: next job pays less
   ▶ loss of job security: more likely to lose job again

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Model summary

1. Job ladder: better job quality and security at higher steps
2. Lower job finding rates in recessions
Job ladder

Employed

$W_{High}$

$W_{Med}$

$W_{Low}$

Unemployed

$W_{High}$

$W_{Med}$

$W_{Low}$

$P_{up}$

$s_1$

$f$

$s_2$

$s_3$

$P_{down}$
Next steps

draft
1. closer to slides, rewrite budget constrains part

changes to model
2. allow rental rate to change
3. make mortgage interest tax deductible

extra exercises
4. run model for 2+ periods
5. decompose role of moving shocks into
   ▶ extensive margin: shocks sample more young
   ▶ intensive margin: everyone’s decisions affected by ex ante moving risk
Mortgage

long-term contract: pay interest and a share of balance \((r_m + \delta)D\)

- loan to value constraint (downpayment \(d\)): \(D/P \leq 1 - d\)
- payment to income constraint: \((r_m + \delta)D/\text{income} \leq \bar{D}\)

fixed origination cost, costless prepayment

default

- no recourse
- move & rent, foreclosure cost as % of house value, utility cost

⇒ if cannot afford payment: do not default, sell house instead
⇒ default only if deep under water \((D > P)\)

subsidy as share of annual payment: low income households with high payment to income ratio, only a share \(\omega\) of households know this
Income process

\[ \log Y_{i,t} = \log W_{i,t}(age) + U_{i,t} \log z + \theta_{i,t} \]

1. job quality: human capital \( W_{i,t} \)
   - 3 steps on job ladder, age profile for each step
   - employed go up, unemployed go down

2. unemployment \( U_{i,t} \in \{0, 1\} \): \( U \) receive fraction \( z \) of income

3. transitory shock \( \theta_{i,t} \sim \text{i.i.d. } \mathcal{N}(0, \sigma_\theta) \)

transition between employment and unemployment

- job security: heterogeneous separation risk \((s_1, s_2, s_3)\)
- job finding rate: initially \( f_H \), go down to \( f_L \) w/prob \( P_{LTU} \)
Business cycle and expectations

business cycle: two-state Markov chain (Boom, Bust)

parameters differ across states

1. labor: job finding rates, prob to become long term unemployed
2. finance: interest rates, borrowing limits, mortgage amortization $\delta$
3. mortgage subsidy is present only in Bust
4. housing: supply, transaction cost, house price expectations

expected house price growth rate

<table>
<thead>
<tr>
<th>Today</th>
<th>Boom</th>
<th>Bust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boom</td>
<td>$g_1$</td>
<td>$g_2$</td>
</tr>
<tr>
<td>Bust</td>
<td>$g_3$</td>
<td>$g_4$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tomorrow</th>
<th>Boom</th>
<th>Bust</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g_1$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$g_2 &lt; 0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$g_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$g_4$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$g_1$ – steady growth
$g_2 < 0$ – housing bust
$g_3$ – recovery
$g_4$ – no recovery
Computation

Individual household problem

- 11 state variables
  - age, income, employment, homeownership, mortgage debt, net other assets, moving shock, policy awareness, business cycle, $P_1, P_2$
- 7 choice variables
  - consumption, saving/borrowing, housing, heloc/credit card balance, credit card default, mortgage prepayment and default

Solution algorithm

1. solve individual problem on a grid
2. integrate wrt distribution of individual characteristics
3. find $P_1$ & $P_2$ that clear housing market

Key features

1. economics: e.g. no default above water, no prepay if networth < 0
2. programming: GPU computing, optimize implementation
3. hardware: Amazon cloud workstation 35TFlops $\approx$ 500 laptops
## Preference parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Internal</th>
<th>Source / Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>risk aversion, $\gamma$</td>
<td>2</td>
<td>N</td>
<td>standard</td>
</tr>
<tr>
<td>Cobb-Douglas weight on H, $\alpha$</td>
<td>0.2</td>
<td>N</td>
<td>standard (spending share)</td>
</tr>
<tr>
<td>discount factor, $\beta$</td>
<td>0.91</td>
<td>Y</td>
<td>mean savings 2007</td>
</tr>
<tr>
<td>housing services, $(H_1, H_2)$</td>
<td>(7.9, 94)</td>
<td>Y</td>
<td>house prices 2007 (Zillow)</td>
</tr>
<tr>
<td>cons. equiv. $(H_1, H_2)^{\alpha/(1-\alpha)}$</td>
<td>(1.7, 3.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>utility cost of moving</td>
<td>16%</td>
<td>Y</td>
<td>moving rate 2007 (SCF)</td>
</tr>
<tr>
<td>util. cost of mortgage default</td>
<td>0.5%</td>
<td>Y</td>
<td>mortgage delinq. rate 2007</td>
</tr>
<tr>
<td>util. cost of cr. card default</td>
<td>37%</td>
<td>Y</td>
<td>cr. card delinq. rate 2007</td>
</tr>
</tbody>
</table>

Internal parameter values chosen so that model matches data in 2007
External parameter values measured from data or from other papers
## Finance and housing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>deposit</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>interest rate</td>
<td>-2.7% → -1.7%</td>
<td>Fed</td>
</tr>
<tr>
<td><strong>mortgage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>downpayment</td>
<td>12% → 18%</td>
<td>Freddie Mae</td>
</tr>
<tr>
<td>payment/income</td>
<td>50% → 40%</td>
<td>Greenwald (2016)</td>
</tr>
<tr>
<td>amortization</td>
<td>1/30 → 1/25</td>
<td>term ≈ 1/δ</td>
</tr>
<tr>
<td><strong>heloc</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loan to value</td>
<td>85% → 60%</td>
<td>standard</td>
</tr>
<tr>
<td>interest rate</td>
<td>5.3% → 1.6%</td>
<td>Fed</td>
</tr>
<tr>
<td><strong>credit card</strong></td>
<td></td>
<td></td>
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<tr>
<td>debt to income</td>
<td>100% → 80%</td>
<td>SCF</td>
</tr>
<tr>
<td>interest rate</td>
<td>10.4% → 11.6%</td>
<td>Fed</td>
</tr>
<tr>
<td><strong>housing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>transaction cost</td>
<td>6% → 9%</td>
<td>standard</td>
</tr>
<tr>
<td>stock $\bar{H}_1$ per person</td>
<td>.32 → .33</td>
<td>SCF</td>
</tr>
<tr>
<td>stock $\bar{H}_2$ per person</td>
<td>.32 → .32</td>
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## Income process

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<td>unempl. replacement, $z$</td>
<td>$0.7 \rightarrow 0.5$</td>
<td>Davis &amp; von Watcher 2011</td>
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<tr>
<td>transition prob: $P_{up}, P_{down}$</td>
<td>$0.05, 0.5$</td>
<td>DW2011</td>
</tr>
<tr>
<td>job finding rates, $f_H, f_L$</td>
<td>$0.9, 0.6 \rightarrow 0.6, 0.3$</td>
<td>Shimer 2012, DW2011</td>
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<td>separation rates, $s_1, s_2, s_3$</td>
<td>$0.3, 0.2, 0.1$</td>
<td>DW2011, mean: Shimer 2012</td>
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<tr>
<td>prob. of long term U, $P_{LTU}$</td>
<td>$0.1 \rightarrow 0.3$</td>
<td>Kosanovich &amp; Sherman 2015</td>
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Business cycle and expectations

- aggregate state transition probabilities
  Boom → Bust: 0 (robustness: 0 – 10%)
  Bust → Boom: 25% (robustness: 10% – 30%)

- expected house price growth
  targets: expected growth 6.6% in Boom and 5% in Bust
  (Case, Shiller, Thompson survey for 2007 and 2009)

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<td>Bust 20%</td>
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back to overview
Mortgage policy

Home Affordable Modification Program

subsidy $\approx 40\%$ of annual mortgage payment (HAMP average)

eligibility requirements

1. payment to income ratio $> 31\%$ (actual requirement)
2. payment to income ratio $< 31\%/(1 - 0.4) = 52\%$ (able to afford reduced payment)
3. income: in Low or Med group (experience financial hardship)

policy awareness

- 7% homeowners with mortgages eligible in model
- 1.2 million applied in data by end 2009
- adjusting for sample, it is 3% applications in model
- awareness $\omega = 3\% / 7\% = 0.44$
Fewer loan originations

- Median house price, 2007$k
- New mortgages/10, 2007$b
- New heloc, 2007$b

Unemployment
Mortgage delinquency
Credit card delinquency
Jarosch (2015): earnings and wage loss
Jarosch (2015): separation risk
Jarosch (2015): decomposition

[Graph showing wage relative to counterfactual over months before and after separation, with separate areas for Negotiation Rents, Employer Capital, and Human Capital.]
Young people move more

Housing market is illiquid
Young movers more sensitive to credit and labor market conditions

source: 2007-2009 American Community Survey
Moving rates: data


For more information on the ACS, see <http://www.census.gov/acs/www>

Young Adults on the Move?

Mover rate (Percent)

Recession and Postrecession Movers by Age

-5 0 5 10 15 20 25 30 35 40

Difference in migration rate

Average migration rate

2007–2009 ACS

2010–2012 ACS

Young Adults (18-34)

American Community Survey asks: "Did this person live in this house or apartment 1 year ago?"

Note: Applies to movers age 1 and over.


United States Census Bureau

U.S. Department of Commerce

Economics and Statistics Administration

U.S. CENSUS BUREAU

census.gov

back
many households move for reasons not captured in standard lifecycle problem

about 1/2 for both renters, and homeowners

I model these reasons as moving shock, that is age-specific and differs for owners and renters

source: Ihrke (2014)
Preferences and housing

- life cycle with $L$ work years, $R$ retirement years

$$V_t = \left((1 - \beta)U_t^{1-1/\sigma} + \beta F_t^{1-1/\sigma}\right)^{\frac{1}{1-1/\sigma}}$$  \quad (3)

$$U_t = C_t^{1-\alpha} H_t^\alpha$$  \quad (4)

$$F_t = \mathbb{E}_t \left[V_{t+1}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}$$  \quad (5)

$$F_T = (1 - \beta^R) C_{T+1}^{1-\alpha} H_{T+1}^\alpha$$  \quad (6)

baseline case: $\gamma = 1/\sigma$

- proportional utility cost of moving: $V_t^{move} = (1 - \tau_{move})V_t$

- retirees do not move, consume pension and assets
Balance sheet details

- **deposits** pay interest rate $r_d$

- **houses** have transaction costs proportional to price, paid by seller, maintenance cost and property tax

- **credit cards** have interest rate $r_c > r_d$
  - limit $\bar{b} \geq$ debt/income ratio
  - default has utility penalty, cannot borrow in same year

- **mortgage** $D$ has mortgage rate $r_c > r_m > r_d$
  - long-term contract with annual payment $(r_m + \delta)D$
  - downpayment (loan to value) constraint $D/P \leq 1 - d$
  - payment to income ratio $\leq \bar{D}$
  - fixed origination cost $FC_m$
  - costless prepayment
  - default: utility penalty, foreclosure cost, cannot borrow in same year
  - subsidy available to low income households with high payment to income ratio, only a share $\omega$ of households aware

- **heloc** is short-term credit, $r_c > r_h > r_d$
  - limit $(heloc + D)/P \leq v$, fixed cost $FC_h$, defaults with mortgage
Budget constraint: renter

\[ B' = (1 + \tilde{r})B + Y - C - p - (P_{H'}d + FC_m) \times 1_{H'>0} \]  \hspace{1cm} (7)

\[ \tilde{r} = \begin{cases} 
  r_d & \text{if } B \geq 0 \\
  r_c & \text{if } B < 0 
\end{cases} \]  \hspace{1cm} (8)

\[ D' = (1 - d)P_{H'} \times 1_{H'>0} \]  \hspace{1cm} (9)
Budget constraint: owner, not moving

\[ B' = (1 + \tilde{r})B + Y - C - t_{\text{maint}} P_H - (r_m + \delta)D_i (1 - \text{sub}) - FC_{\text{heloc}} \times 1_{\text{heloc}} \]

\[ D' = (1 - \delta)D \]

\[ \tilde{r} = \begin{cases} 
  r_d, & \text{if } B \geq 0 \\
  r_c, & \text{if } B < 0, \text{ no heloc} \\
  r_h, & \text{if } B < 0, \text{ heloc, } -B + D \leq \nu P_H, \\
  \frac{\nu P_H - D}{-B} r_h + (1 - \frac{\nu P_H - D}{-B}) r_c, & \text{if } B < 0, \text{ heloc, } -B + D > \nu P_H, 
\end{cases} \]
Budget constraint: owner, moving

define $\tilde{B}' = (1 + \tilde{r})B + Y - C - t_{\text{maint}}P_H$

$$\tilde{r} = \begin{cases} 
    r_d & \text{if } B \geq 0 \\
    r_c & \text{if } B < 0 
\end{cases}$$

if no mortgage default

$$B' = \tilde{B}' + (1 - t)P_H - (r_m + 1)D - (P_H'd + FC_m) \times 1_{H'>0}$$
$$D' = (1 - d)P_{H'} \times 1_{H'>0}$$

if mortgage default

$$B' = \tilde{B}' + \max\{0, (1 - t - t_F)P_H - (r_m + 1)D\}$$
$$D' = 0$$
Lifecycle income profile: data

Labor income relative to the mean among the employed (2007 SCF)
Lifecycle income profile: model

Labor income relative to the mean among the employed (2007 SCF)
Computation

Individual household problem

- 11 state variables
  - 3 aggregate: business cycle (Boom or Bust), $P_1$, $P_2$
  - 8 individual: age, income, employment, homeownership, mortgage debt, net other assets, moving shock, policy awareness

- 7 choice variables: consumption, saving/borrowing, housing, heloc/credit card balance, credit card default, mortgage prepayment and default

Solution algorithm

1. solve household problem on a grid
   ✓ value function iteration, finite horizon: exact solution in $L$ steps
2. predict choices for 6062 households in SCF as functions of $P_1$ & $P_2$
3. find $P_1$ & $P_2$ that clear housing market

Key features

1. economics: e.g. no default underwater, no prepay if networth < 0
2. programming: GPU computing, optimize implementation
3. hardware: Amazon Cloud p2.8xlarge ~ 500 laptops
### Income process

#### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source / Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>unempl. replacement, $z$</td>
<td>$0.7 \rightarrow 0.5$</td>
<td>Davis &amp; von Watcher 2011</td>
</tr>
<tr>
<td>transition prob: $P_{up}, P_{down}$</td>
<td>0.05, 0.5</td>
<td>DW2011</td>
</tr>
<tr>
<td>job finding rates, $f_H, f_L$</td>
<td>0.9, 0.6 $\rightarrow$ 0.6, 0.3</td>
<td>Shimer 2012, DW2011</td>
</tr>
<tr>
<td>separation rates, $s_1, s_2, s_3$</td>
<td>0.3, 0.2, 0.1</td>
<td>DW2011, mean: Shimer 2012</td>
</tr>
<tr>
<td>prob. of long term U, $P_{LTU}$</td>
<td>0.1 $\rightarrow$ 0.3</td>
<td>Kosanovich &amp; Sherman 2015</td>
</tr>
</tbody>
</table>

#### Income loss from unemployment, %

<table>
<thead>
<tr>
<th></th>
<th>Short-term (2 years)</th>
<th>Long-term (10 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boom</td>
<td>Bust</td>
</tr>
<tr>
<td>3+ years tenure, Data</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>3+ years tenure, Model</td>
<td>18</td>
<td>27</td>
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<tr>
<td>1-2 years tenure, Model</td>
<td>9</td>
<td>20</td>
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<tr>
<td>Average job loser, Model</td>
<td>14</td>
<td>24</td>
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## Finance and housing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source / Target</th>
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</thead>
<tbody>
<tr>
<td>deposit</td>
<td>interest rate</td>
<td>-2.7% → -1.7%</td>
</tr>
<tr>
<td>downpayment</td>
<td>12% → 18%</td>
<td>Freddie Mae</td>
</tr>
<tr>
<td>payment/income</td>
<td>50% → 40%</td>
<td>Greenwald (2016)</td>
</tr>
<tr>
<td>mortgage amortization</td>
<td>1/30 → 1/25</td>
<td>term (\approx 1/\delta)</td>
</tr>
<tr>
<td>origination cost</td>
<td>$1700</td>
<td>standard</td>
</tr>
<tr>
<td>foreclosure cost</td>
<td>10%</td>
<td>standard</td>
</tr>
<tr>
<td>interest rate</td>
<td>3.6%</td>
<td>Fed</td>
</tr>
<tr>
<td>mortgage</td>
<td>loan to value</td>
<td>85% → 60%</td>
</tr>
<tr>
<td>heloc fixed cost</td>
<td>$100</td>
<td>standard</td>
</tr>
<tr>
<td>interest rate</td>
<td>5.3% → 1.6%</td>
<td>Fed</td>
</tr>
<tr>
<td>credit card</td>
<td>debt to income</td>
<td>100% → 80%</td>
</tr>
<tr>
<td>interest rate</td>
<td>10.4% → 11.6%</td>
<td>SCF</td>
</tr>
<tr>
<td>house</td>
<td>rental cost</td>
<td>$10,000 / year</td>
</tr>
<tr>
<td>maintenance, tax</td>
<td>2%</td>
<td>standard</td>
</tr>
<tr>
<td>transaction cost</td>
<td>6% → 9%</td>
<td>standard</td>
</tr>
<tr>
<td>stock per person</td>
<td>.319, .318 → .338, .321</td>
<td>SCF</td>
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</tbody>
</table>
## Results: model vs data

<table>
<thead>
<tr>
<th></th>
<th>Delinq. rate, %</th>
<th>Networth</th>
<th>House Price/Drop</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Cr.card Mort Non-H H Small Large Mean</td>
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<tr>
<td>Model Boom</td>
<td>4.1 3.0 19.4 56</td>
<td>151 267</td>
<td>209</td>
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<tr>
<td>Data 2007</td>
<td>4.0 2.7 19.4 58</td>
<td>149 264</td>
<td>206</td>
</tr>
<tr>
<td>Model Bust</td>
<td>7.2 7.5 20.2 35</td>
<td>32% 21%</td>
<td>25%</td>
</tr>
<tr>
<td>Data 2009</td>
<td>6.8 8.6 19.8 39</td>
<td>15% 15%</td>
<td>15%</td>
</tr>
<tr>
<td>Data 2012</td>
<td>2.9 10.4</td>
<td>33% 29%</td>
<td>31%</td>
</tr>
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</table>
### Results: subsidy, unemployment, moving shock

<table>
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<tr>
<td>Data 2012</td>
<td>2.9 10.4</td>
<td></td>
<td>33% 29% 31%</td>
</tr>
<tr>
<td>No subsidy</td>
<td>8.9 11.0</td>
<td></td>
<td>42% 29% 34%</td>
</tr>
<tr>
<td>No unemployment</td>
<td></td>
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<td>Model 2007</td>
<td>3.8 2.0</td>
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<td>159 280 219</td>
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<tr>
<td>Model 2009</td>
<td>5.8 4.9</td>
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<td>22% 13% 16%</td>
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<tr>
<td>No moving shock, moving cost unchanged</td>
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</tr>
<tr>
<td>Model 2007</td>
<td>3.7 0.7</td>
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<td>198 369 283</td>
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<tr>
<td>Model 2009</td>
<td>3.9 3.2</td>
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<td>11% 10% 11%</td>
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<td>No moving shock, moving cost adjusted</td>
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<tr>
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<td>3.6 0.8</td>
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<td>217 440 329</td>
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<tr>
<td>Model 2009</td>
<td>5.8 2.4</td>
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<td>8% 14% 12%</td>
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