Unemployment and the US Housing Market during the Great Recession

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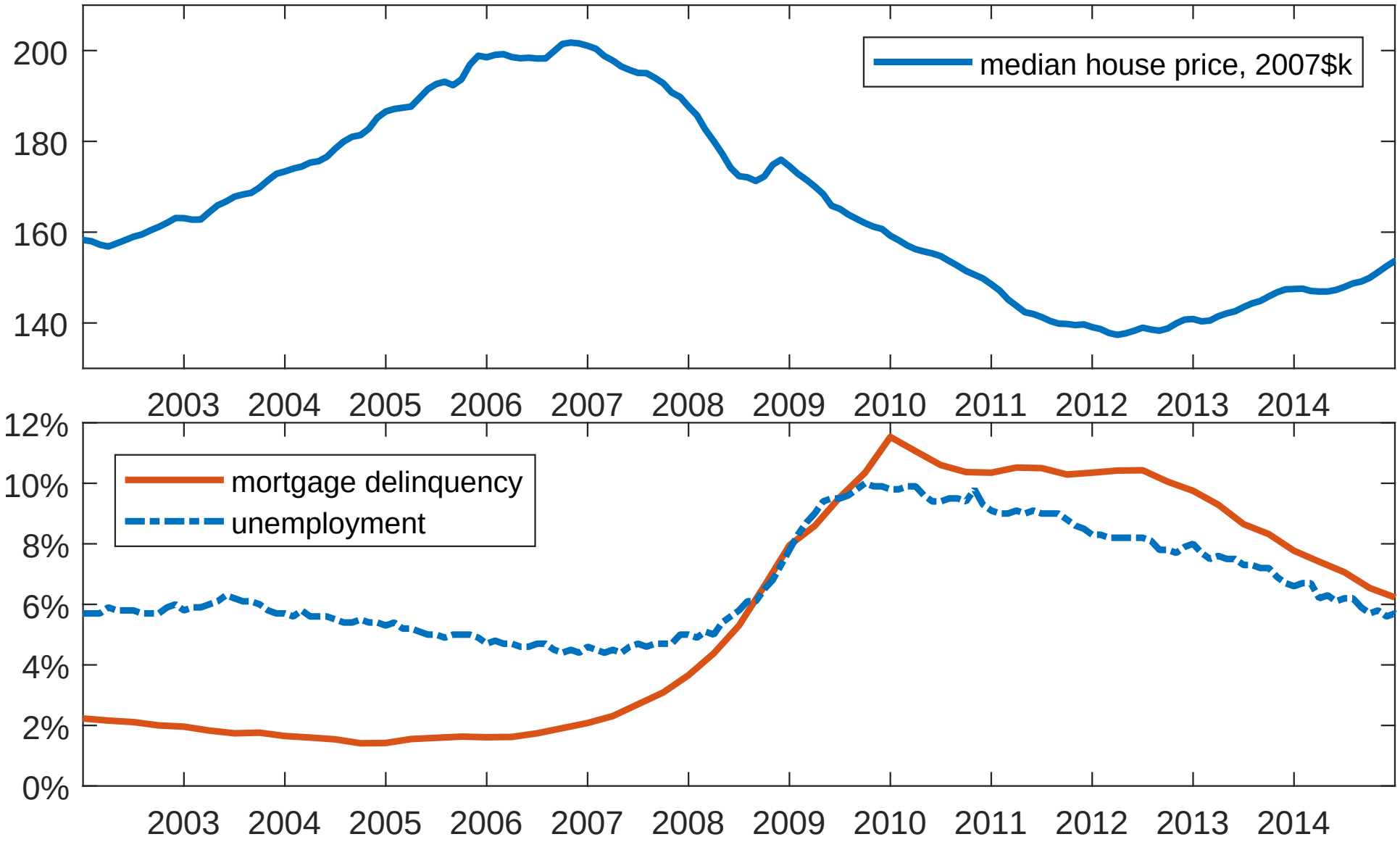
Unemployment and Housing Market



sources: house price (Zillow), delinquencies (Fed), unemployment (Fed)

credit

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

Unemployment rate is signal of future income

- income process matches consequences of job loss over business cycle
  - ⋆ large and long lasting effect on income, worse in recessions
- in the bust, high unemployment lowers expected future income

$\Rightarrow$ lower demand for housing in the bust

micro evidence

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⇒ lower demand for housing in the bust

micro evidence

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

moving rates by age: data model

Overview

Model

- Individual household problems
  - lifecycle consumption-savings choice, rent vs own houses
  - borrow using credit cards, mortgages, home equity lines of credit
- Aggregate economy
  - business cycle driven by 2-state Markov chain: boom and bust
  - equilibrium house prices clear markets given observed supply

Overview

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Quantitative exercises

1. Boom state and 2007 SCF distribution of households
   - choose preference parameters to match aggregates in 2007
   - result: match cross-section of choices by age
2. Bust state and 2009 distribution
   - result: match house price drop, mortgage & credit card delinquencies
   - decompose bust into effects of labor, credit, and other conditions

details

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

- Davis and von Wachter (2011), Jarosch (2015)

Outline

1. Model
2. Quantitative implementation
3. Results

Preferences and housing

- life cycle with L work years, R retirement years

$$\mathbb{E} \sum_{t=age}^{L+R} \beta^{t-age} \frac{U_t^{1-\gamma} - 1}{1-\gamma} \tag{1}$$

$$U_t = C_t^{1-\alpha} H_t^{\alpha} \tag{2}$$

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

details

Balance sheet

- houses: maintenance cost, property tax, transaction cost if sell
- deposits: interest rate r_d
- credit cards: $r_c > r_d$, limit as % of income, default utility cost

Balance sheet

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- mortgage: $r_c > r_m > r_d$, LTV and PTI constraints at origination,
  default utility cost + foreclosure cost,
  subsidy as % of payment to poor w/ high PTI, share ω know

Balance sheet

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  subsidy as % of payment to poor w/ high PTI, share ω know
- home equity line of credit (heloc): $r_c > r_h > r_d$,
  short-term credit
  LTV constraint every year: $(heloc + mortgage)/house\ value$

budget constraints mortgage details

Moving shocks

- 1/2 moves arise endogenously as optimal choice
- 1/2 moves: idiosyncratic shocks, prob. depends on age, own vs. rent

if shock hits, household has to move

- homeowner sells house, renter leaves rental unit
- after that, can buy new house or rent

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implications

1. young move more: movers poor and lose jobs frequently
2. moving risk affects decisions

$1 + 2 \Rightarrow$ demand for housing more sensitive to aggregate conditions

moving rates by age

Consequences of job loss

Micro empirical evidence

micro evidence

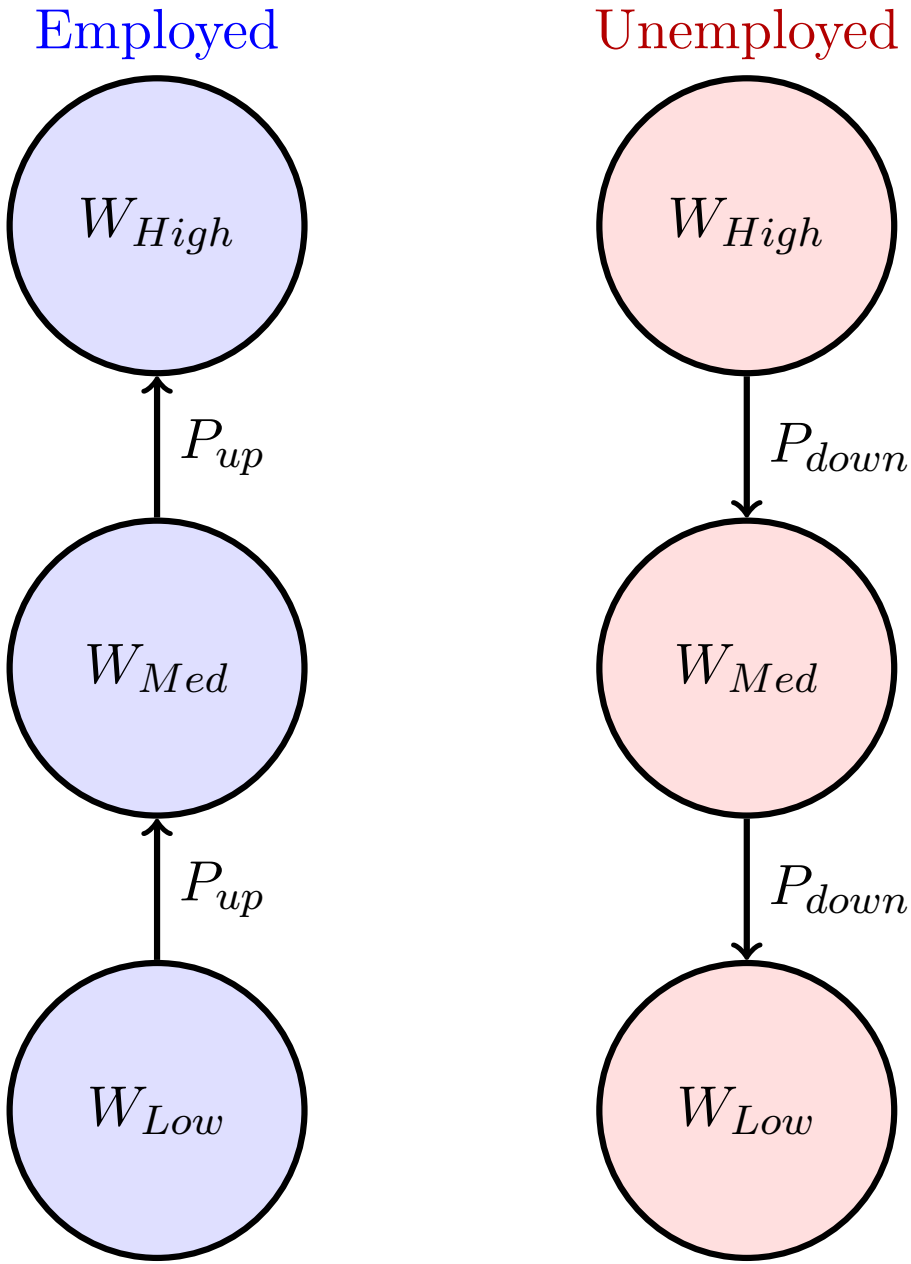
1. large and long lasting effect on income
   - unemployment spell: time to find a job
   - loss of job quality: next job pays less
   - loss of job security: more likely to lose job again
2. worse in recessions

Model summary

model details

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

Job ladder


Employed
Unemployed
W_{High}
W_{High}
P_{up}
P_{down}
W_{Med}
W_{Med}
P_{up}
P_{down}
W_{Low}
W_{Low}

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 δ
3. *mortgage subsidy* is present only in Bust
4. *housing*: supply, transaction cost, house price expectations

expectations

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

Computation

Individual household problem: 11 state & 7 choice variables

var list

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

Outline

1. Model
2. Quantitative implementation
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Quantitative exercise overview

Exercise 2007

- 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 delinq. and moving rates
- check untargeted moments: x-section of households' choices by age

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Exercise 2009

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

Outline

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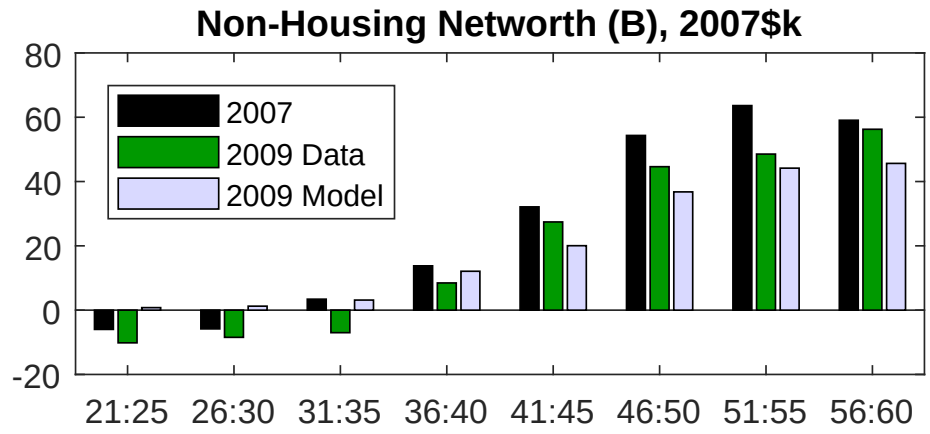
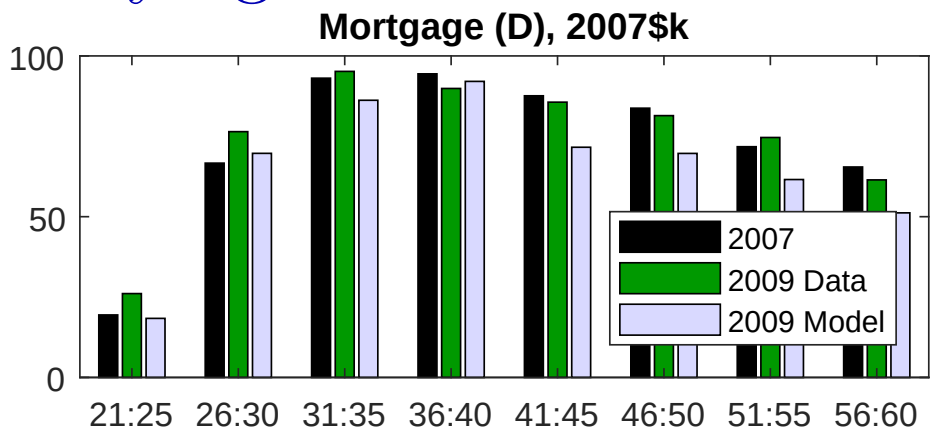
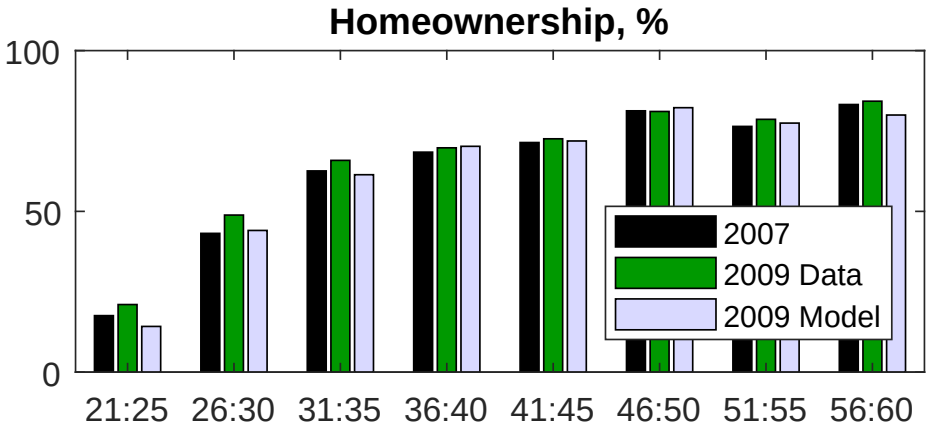
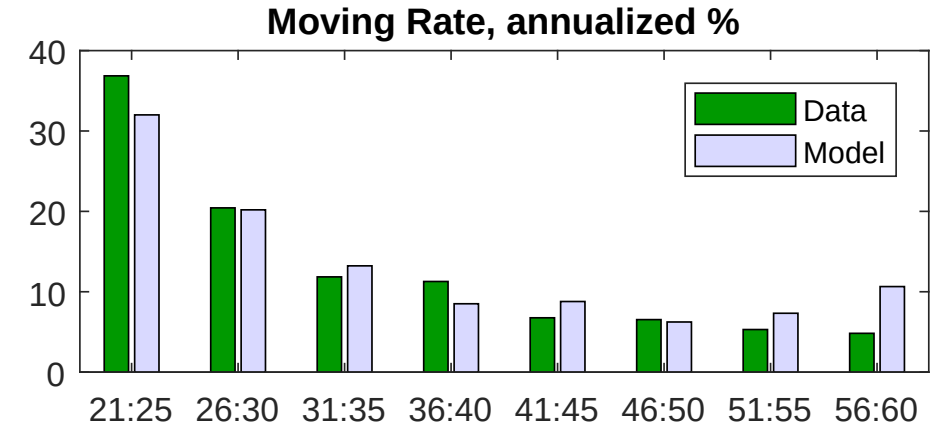
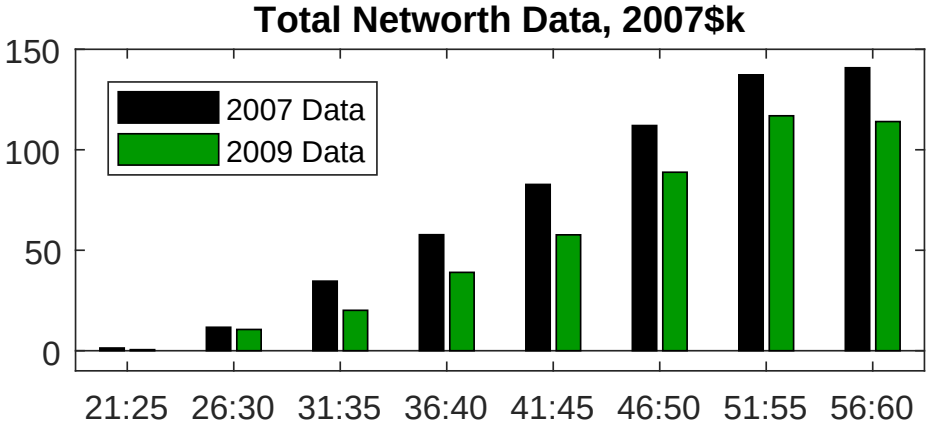
Model fit by age

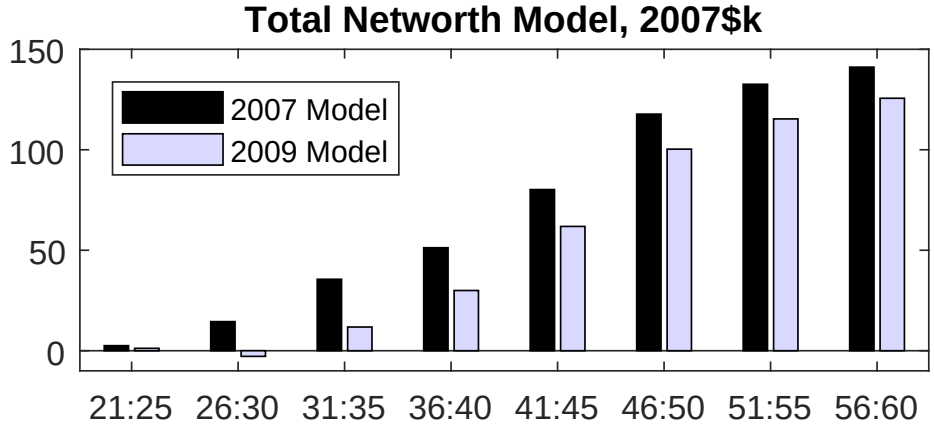












Results: Model vs Data

	Delinquency rate, %		Mean house price
	Credit card	Mortgage	level 2007, drop later
Model 2007	4.1	3.0	209
Data 2007	4.0	2.7	206
Model 2009	7.2	7.5	25%
Data 2009	6.8	8.6	15%
Data 2012	2.9	10.4	31%

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

details

Results: decomposition

In which order shock added → Shock ↘	Added First	Added Last
Financial mkt conditions	**17.8**	**20.8**
Mortgage	11.9	17.5
HELOC	3.4	2.0
Credit Card	2.1	3.0
Labor mkt conditions	**9.1**	**11.4**
House price growth expectations	2.9	6.1
Housing transaction cost	0.6	0.5
Balance sheet	-0.9	2.0
Mortgage subsidy	-10.0	-8.9
All together	25	25

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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Results: subsidy, moving shock

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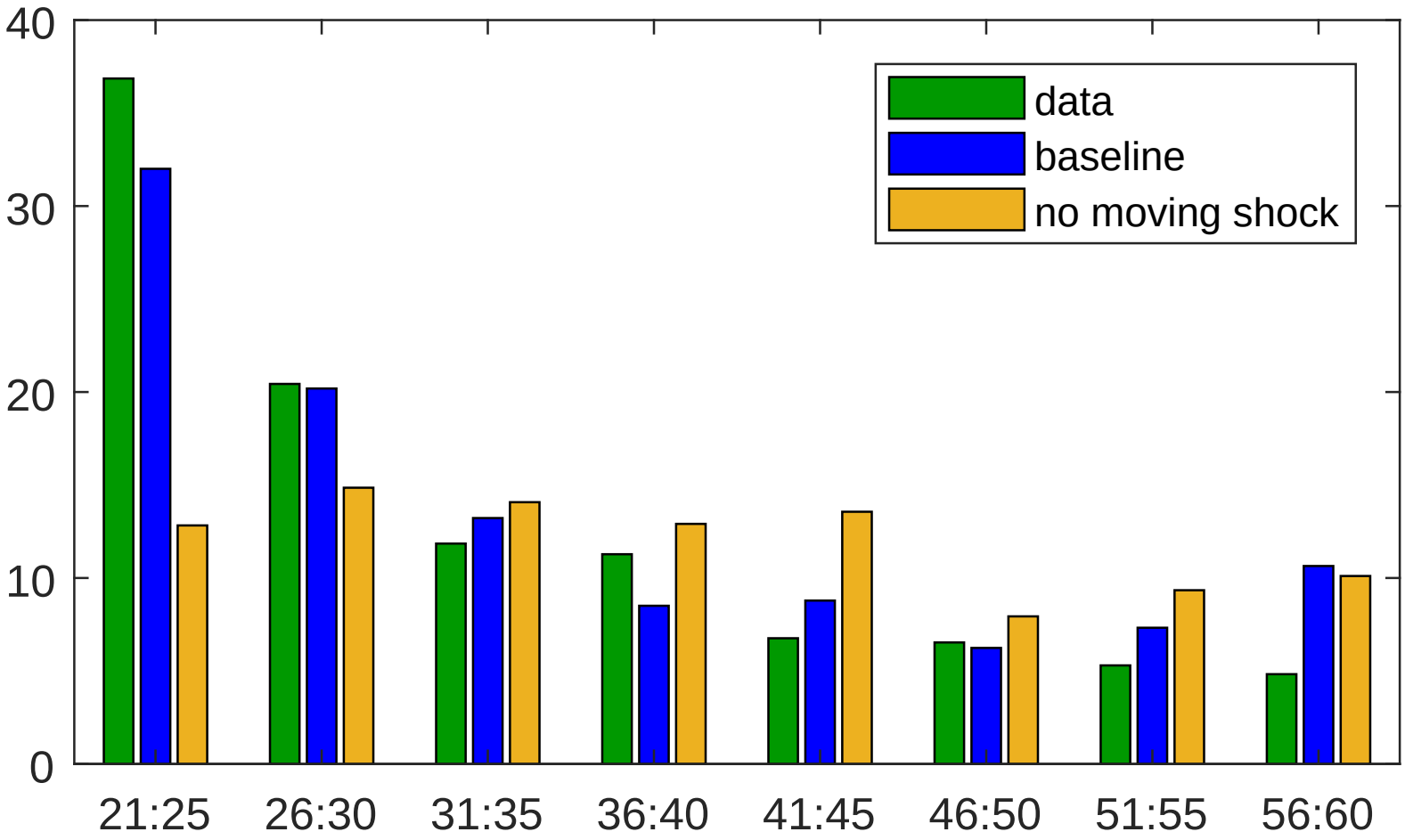
Data 2012	2.9	10.4	31%
No subsidy	8.9	11.0	34%
No moving shock			
Model 2007	3.6	0.8	329
Model 2009	5.8	2.4	12%

details

Moving rates with and without shocks, %



intro

Conclusion

- conditions in which hh live changed a lot during crisis
- is it enough to explain the large decline in house prices?
  - yes, with rich enough income process & moving shocks
- which of these conditions matter more for house prices?
  - tighter credit constraints on mortgages = 1/2
  - 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 total

Appendix

Why did house prices drop so much?

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Main new features

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

Main results

- weak labor market explains 1/3 of house price decline
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- Home Affordable Modification Program prevents extra 1/3 drop

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

$\Rightarrow$ if cannot afford payment: do not default, sell house instead

$\Rightarrow$ 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 ω of households know this

budget constraints | balance sheet

Income process

$$\text{income } \log Y_{i,t} = \underset{1}{\log W_{i,t}(age)} + \underset{2}{U_{i,t} \log z} + \underset{3}{\theta_{i,t}}$$

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

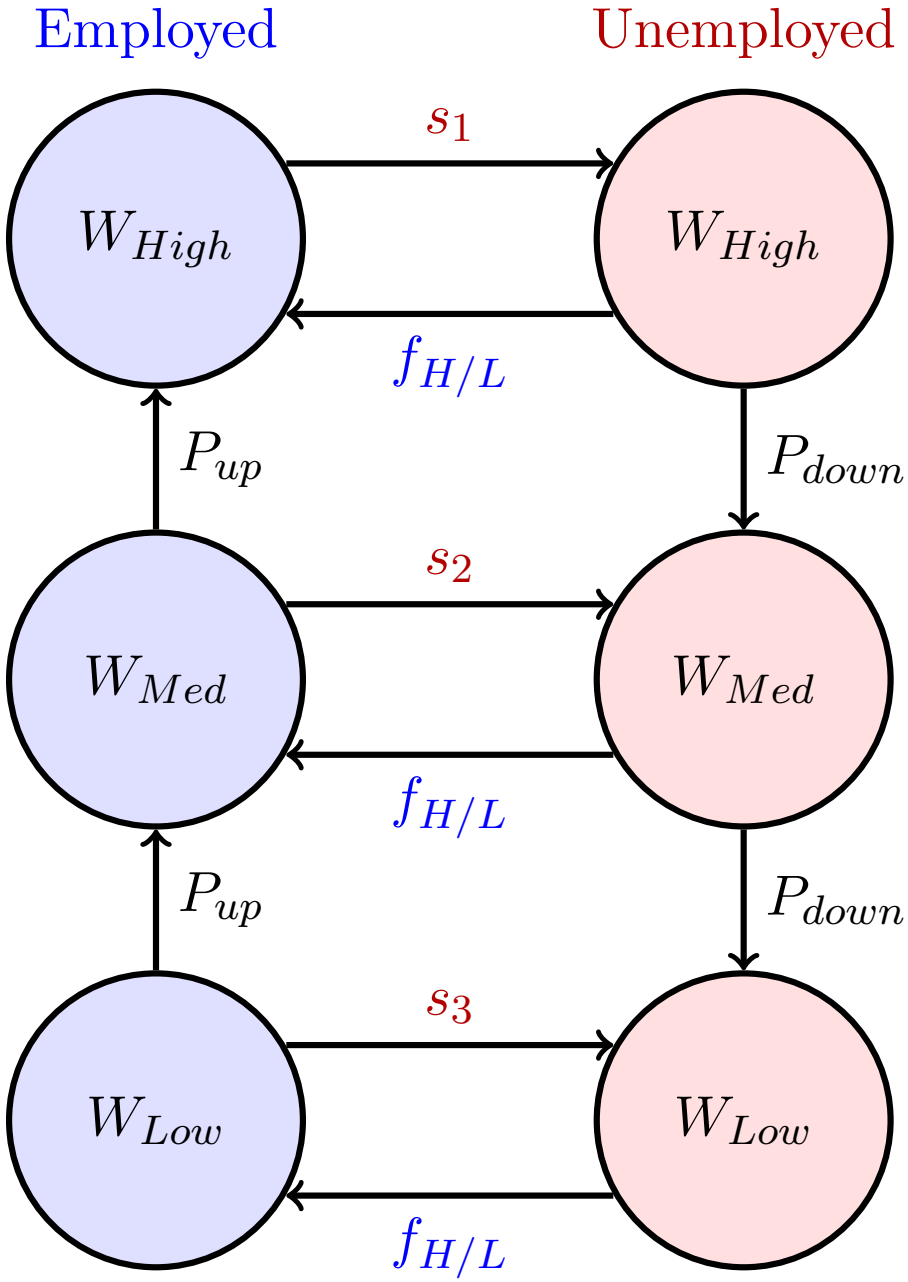
income by age

2. unemployment $U_{i,t} \in \{0, 1\}$: U receive fraction z of income
3. transitory shock $\theta_{i,t} \sim$ 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}

back


Employed
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s_1
W_{High}
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$f_{H/L}$
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P_{down}
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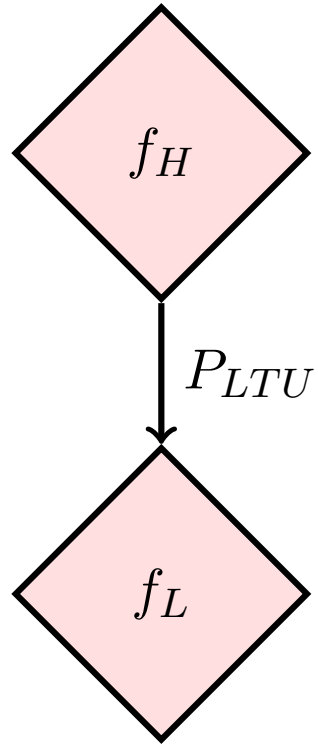
$f_{H/L}$


f_H
P_{LTU}
f_L

back

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 δ
3. *mortgage subsidy* is present only in Bust
4. *housing*: supply, transaction cost, house price expectations

expected house price growth rate

		Tomorrow	
		Boom	Bust
Today	Boom	g_1	g_2
	Bust	g_3	g_4

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

back

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
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Key features

1. economics: e.g. no default above water, no prepay if networth < 0
2. programming: GPU computing, optimize implementation
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back

Preference parameters

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

Internal parameter values chosen so that model matches data in 2007

External parameter values measured from data or from other papers

back to overview

Finance and housing

Parameters that change between Boom → Bust

	Parameter	Value	Source / Target
deposit	interest rate	-2.7% → -1.7%	Fed
mortgage	downpayment	12% → 18%	Freddie Mae
	payment/income	50% → 40%	Greenwald (2016)
	amortization	1/30 → 1/25	term $\approx 1/\delta$
heloc	loan to value	85% → 60%	standard
	interest rate	5.3% → 1.6%	Fed
credit card	debt to income	100% → 80%	SCF
	interest rate	10.4% → 11.6%	Fed
housing	transaction cost	6% → 9%	standard
	stock $\bar{H}_1$ per person	.32 → .33	SCF
	stock $\bar{H}_2$ per person	.32 → .32	SCF

details 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 $\omega = 3\%$ / $7\% = 0.44$

back to overview

Income process

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

details back to overview

Business cycle and expectations

- aggregate state transition probabilities

  Boom $\to$ Bust: 0 (robustness: $0 - 10\%$)

  Bust $\to$ Boom: 25% (robustness: $10\% - 30\%$)

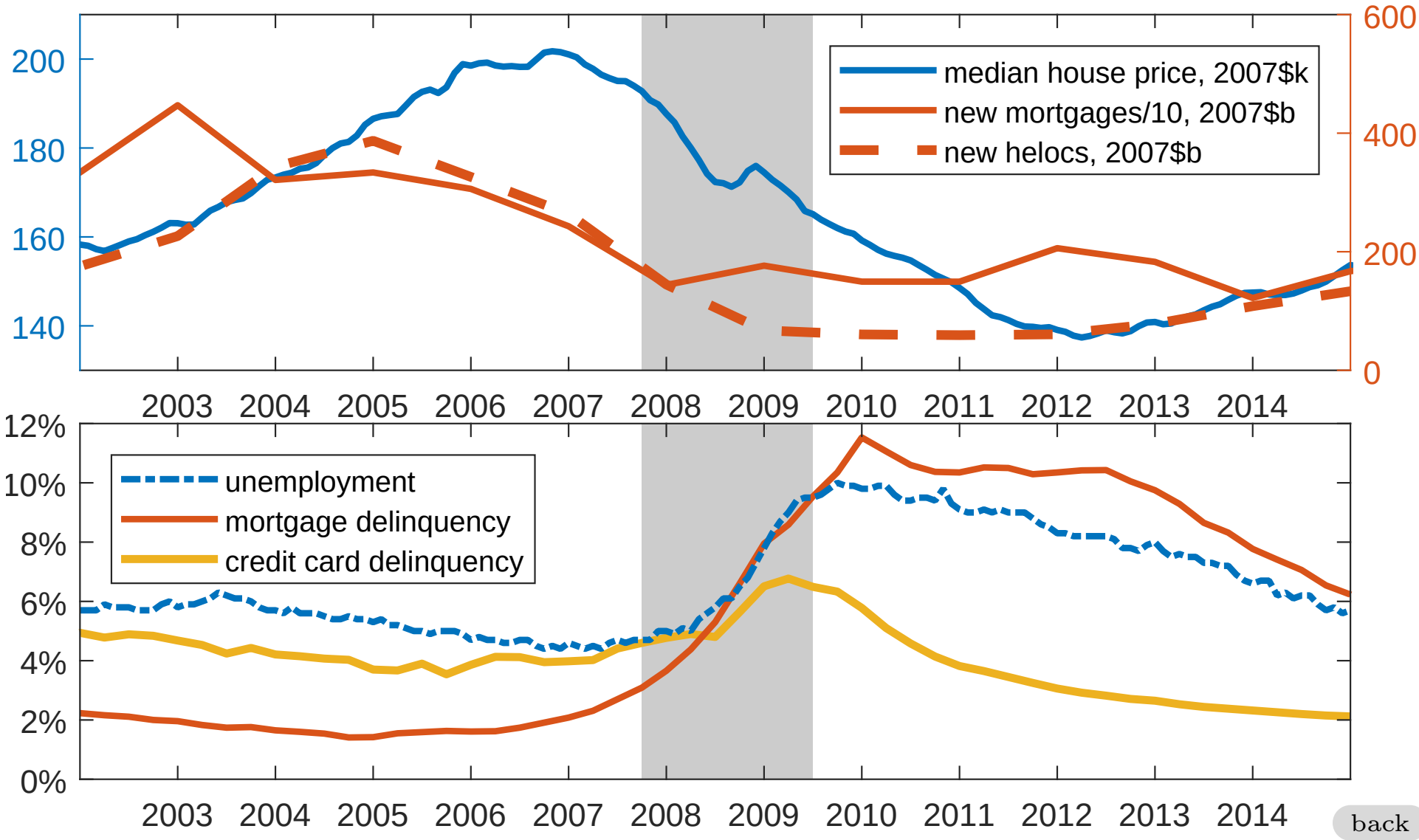
- expected house price growth

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

		Tomorrow	
		Boom	Bust
Today	Boom	6.6%	−20%
	Bust	20%	0

back to overview

Fewer loan originations



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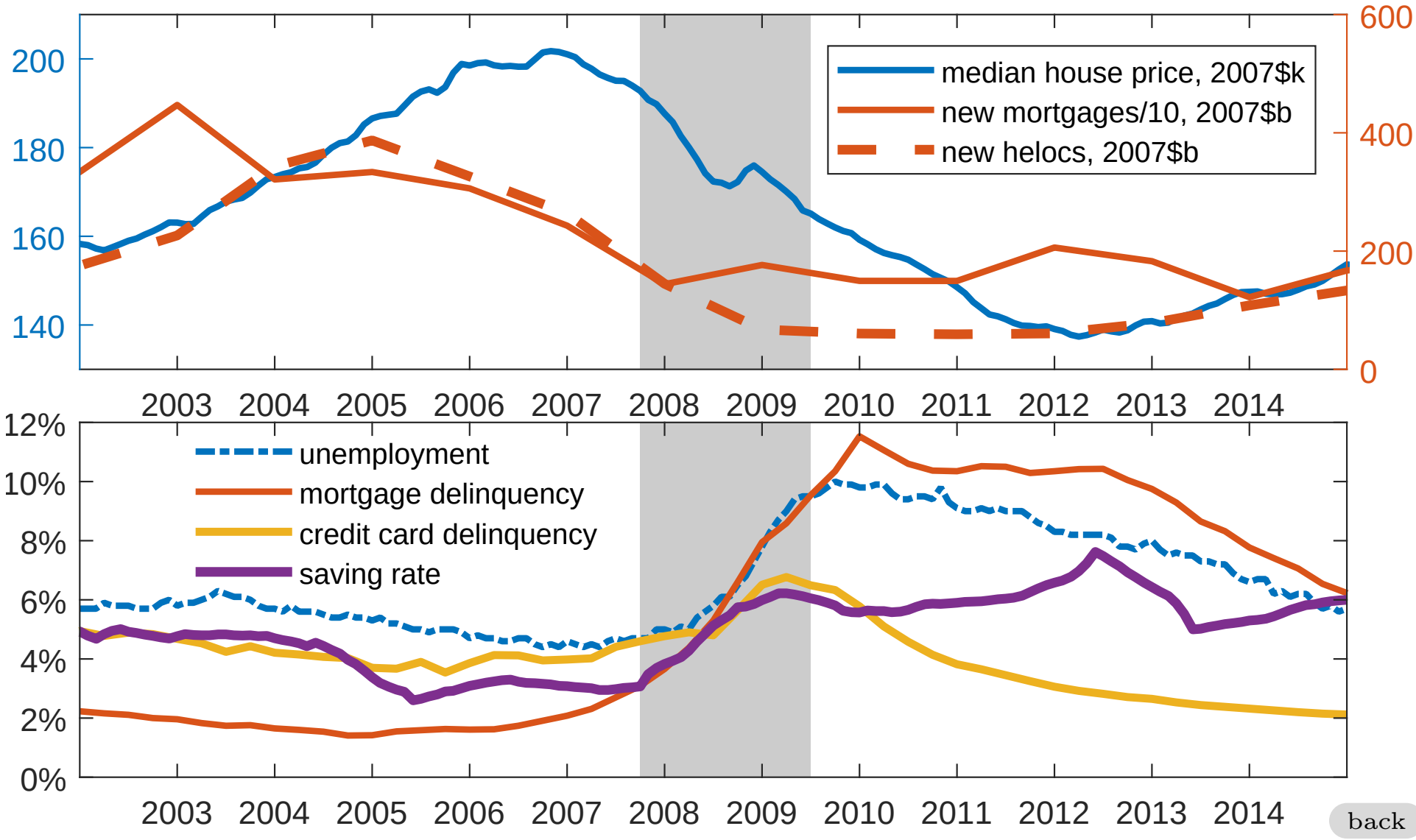
Saving rate up



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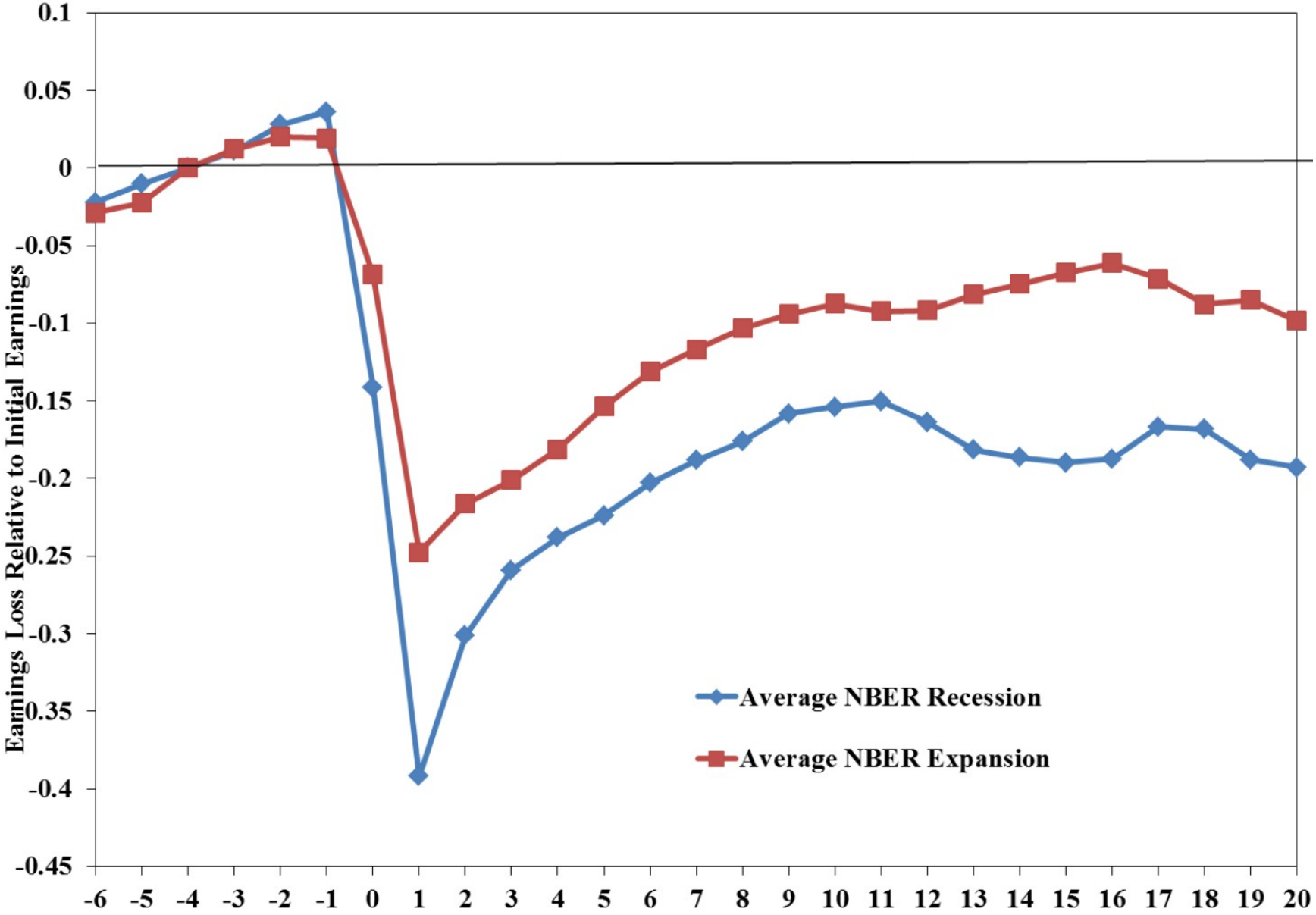
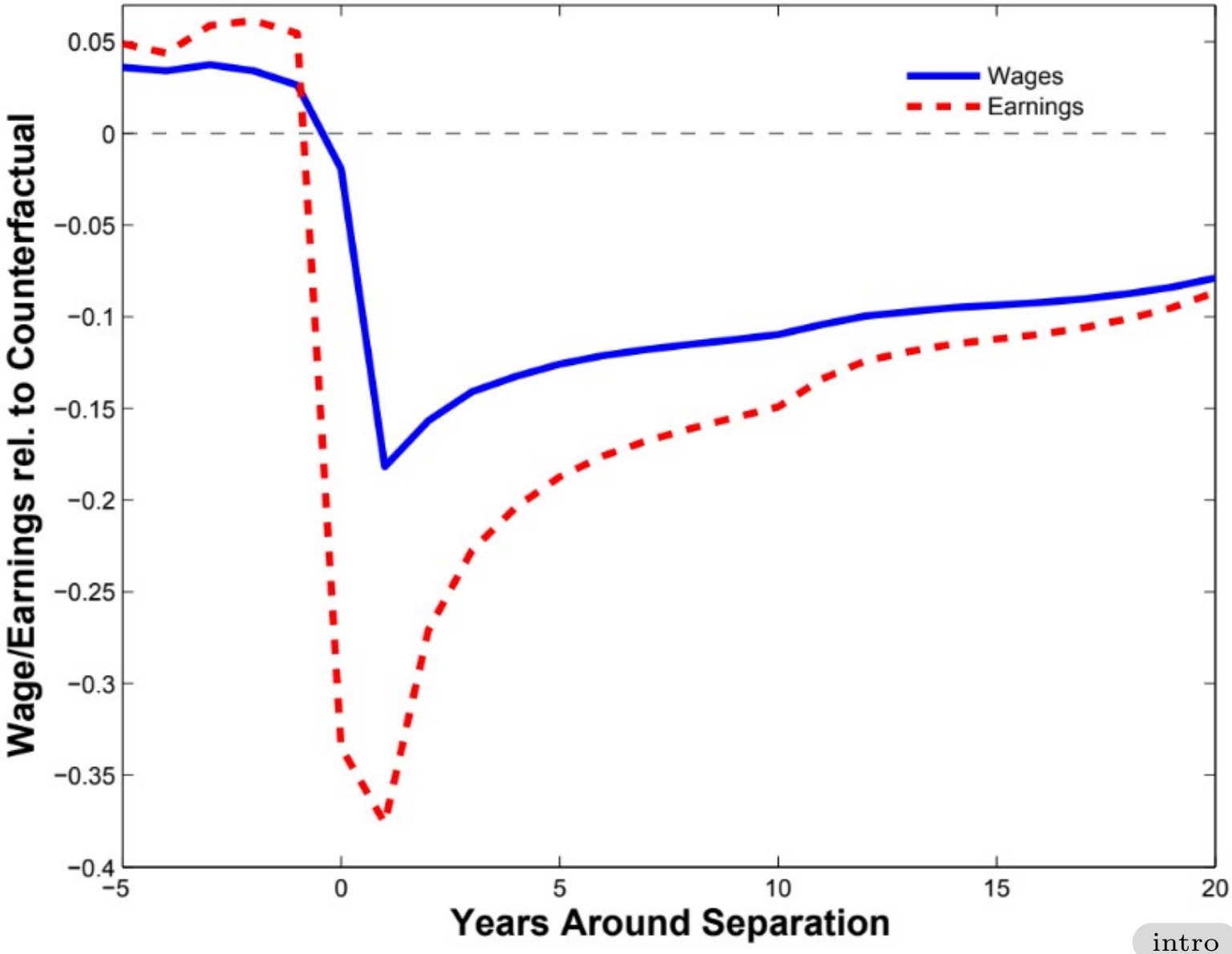
Davis and von Wachter (2011), Figure 5

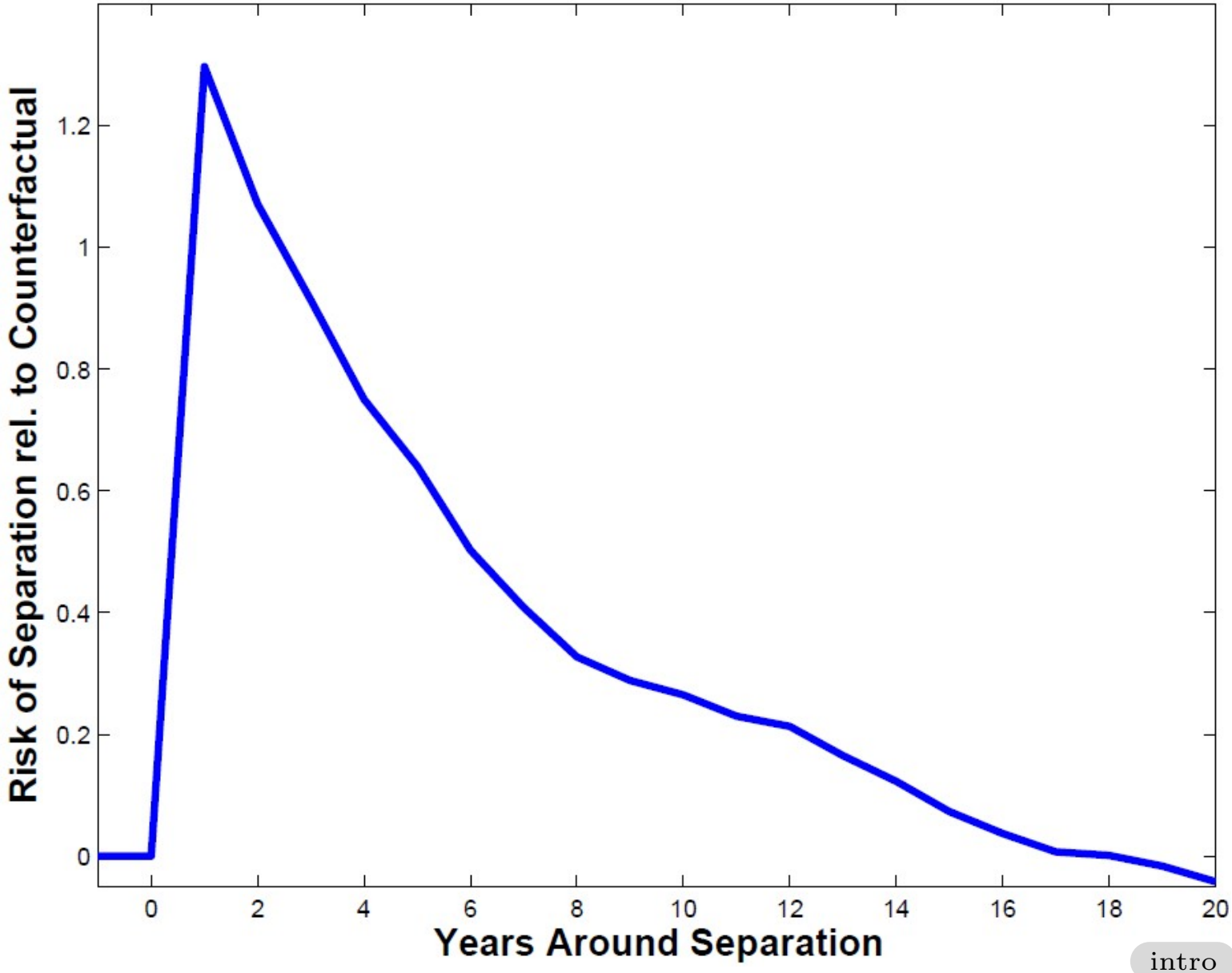


Jarosch (2015): earnings and wage loss

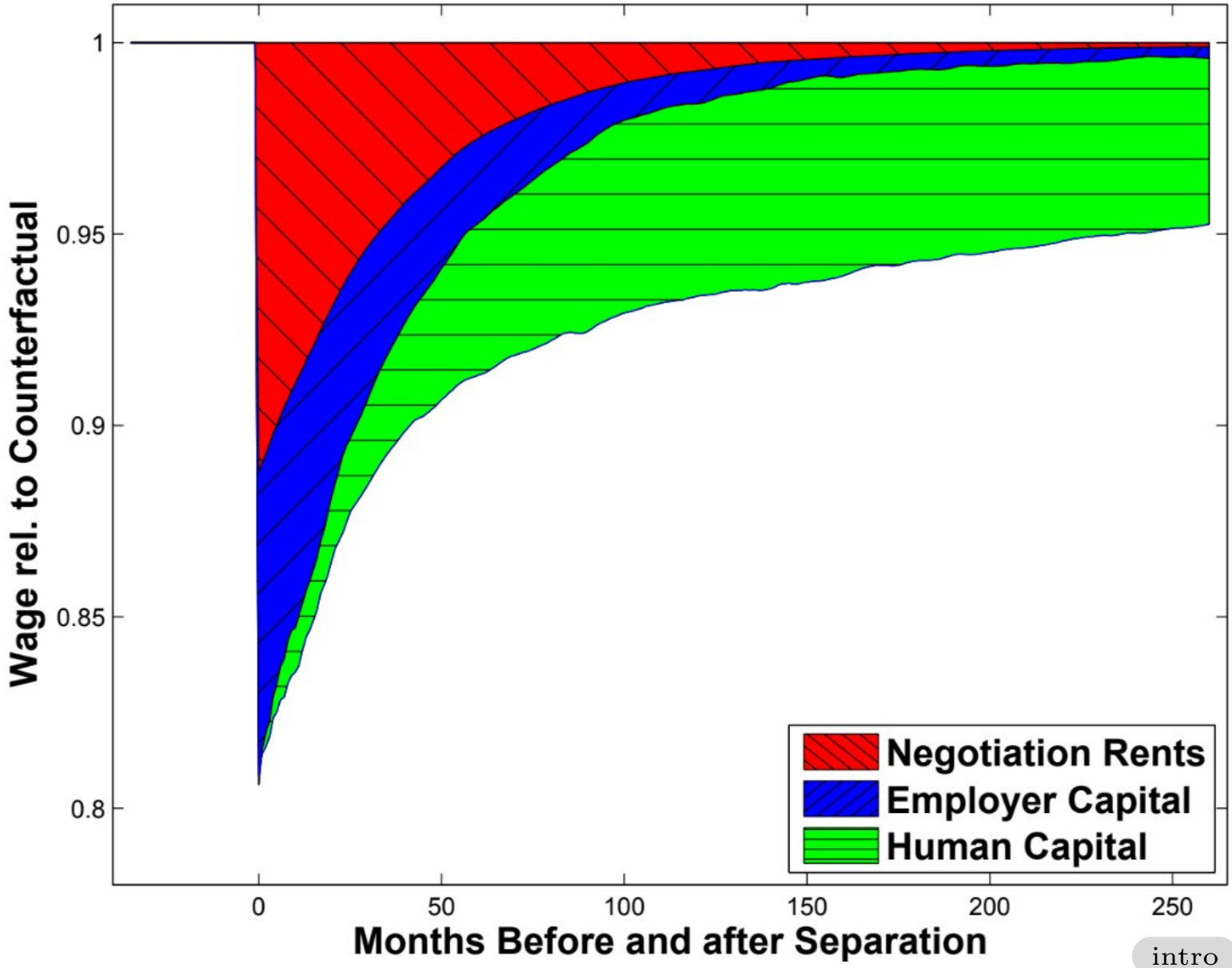


intro income

Jarosch (2015): separation risk



Jarosch (2015): decomposition

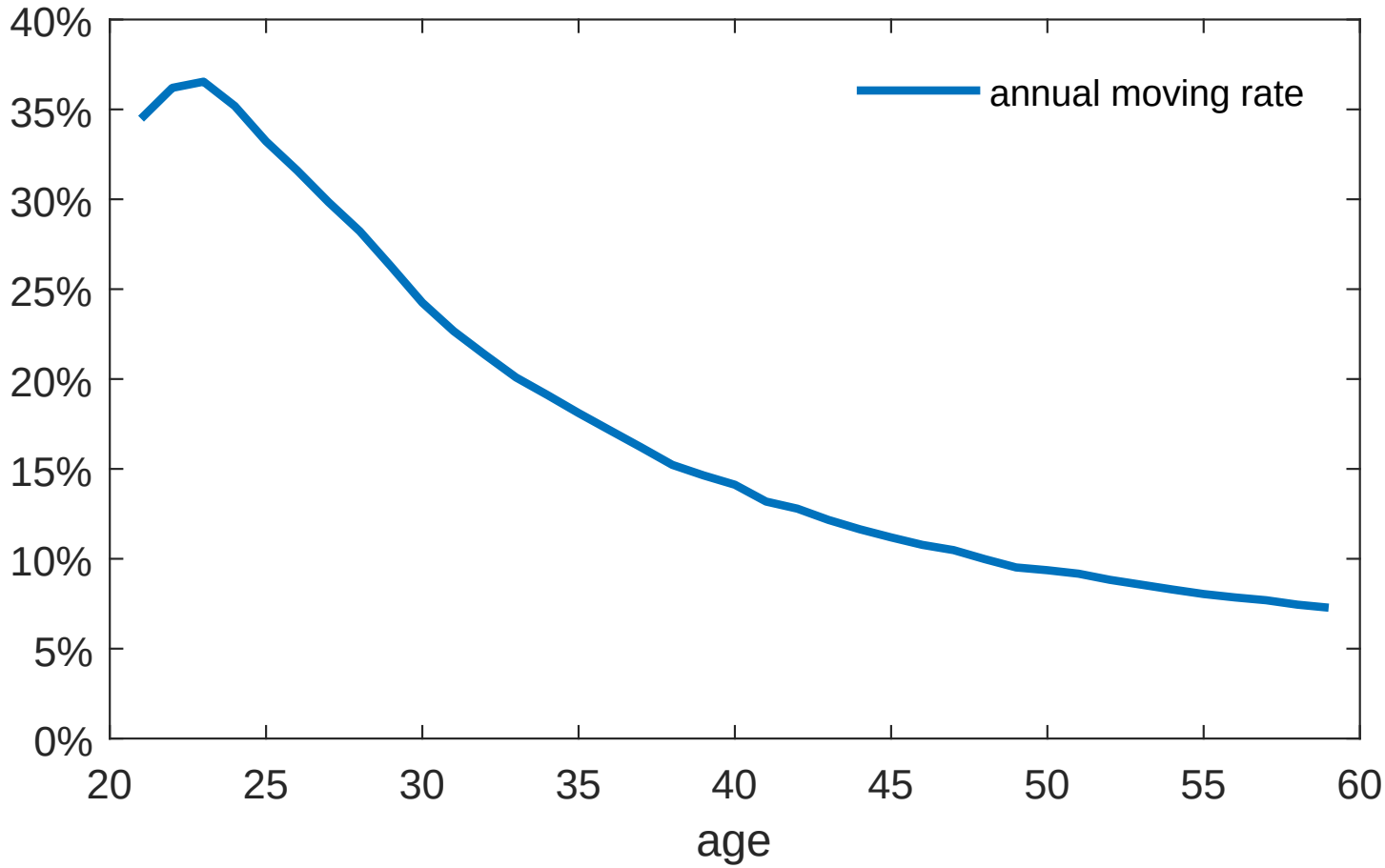


intro income

Young people move more

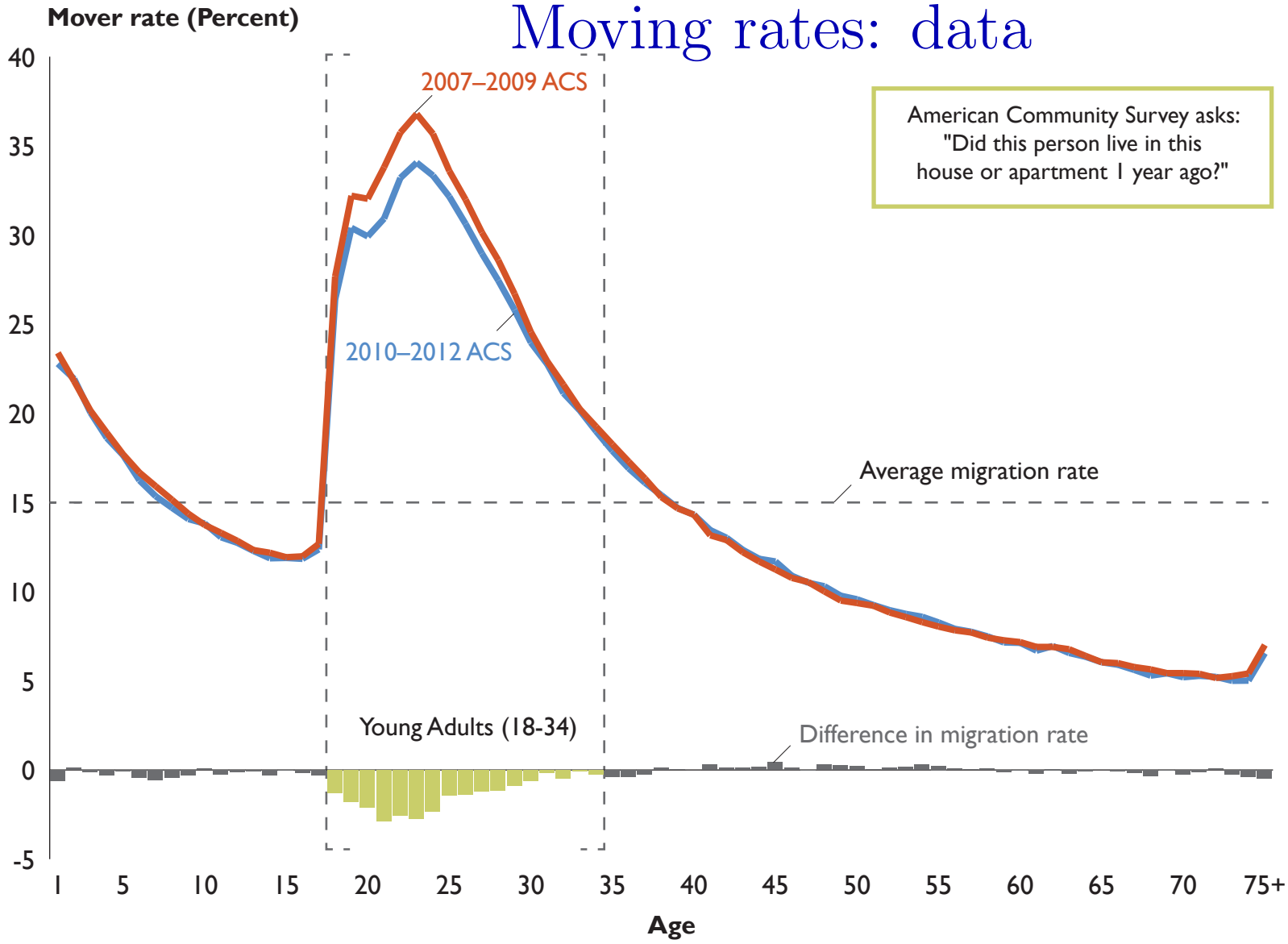
Housing market is illiquid

Young movers more sensitive to credit and labor market conditions



source: 2007-2009 American Community Survey

Moving rates: data



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

Sources: U.S. Census Bureau, 2007–2009 and 2010–2012 American Community Survey 3-Year Estimates.
For more information on the ACS, see <http://www.census.gov/acs/www>

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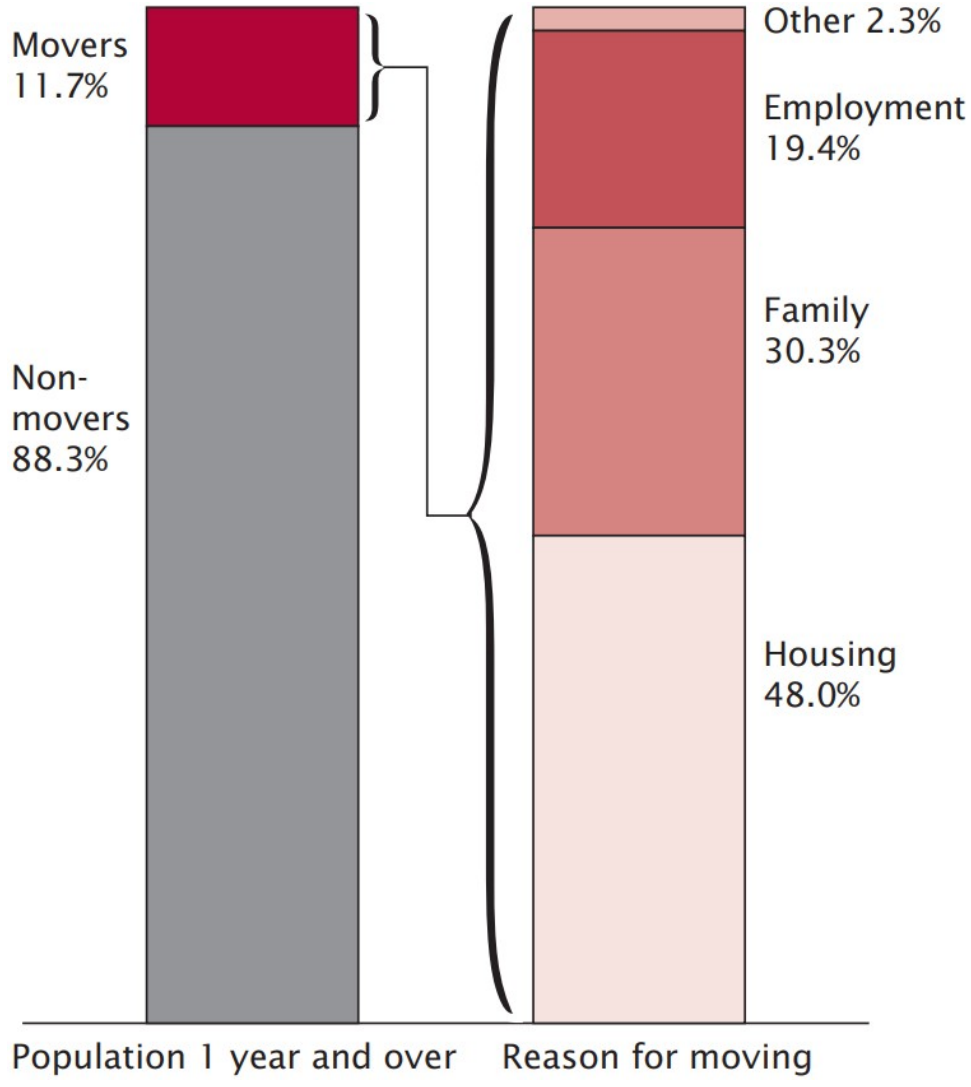
Reasons for moving

- 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)

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Preferences and housing

- life cycle with L work years, R retirement years

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

$$U_t = C_t^{1-\alpha} H_t^{\alpha} \tag{4}$$

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

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

  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

back

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 penality, 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 penality, foreclosure cost, cannot borrow in same year
  - subsidy available to low income households with high payment to income ratio, only a share ω 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

back

Budget constraint: renter

$$B' = (1 + \tilde{r})B + Y - C - p - (P_{H'}d + FC_m) \times \mathbb{1}_{H'>0} \tag{7}$$

$$\tilde{r} = \begin{cases} r_d & \text{if } B \geq 0 \\ r_c & \text{if } B < 0 \end{cases} \tag{8}$$

$$D' = (1 - d)P_{H'} \times \mathbb{1}_{H'>0} \tag{9}$$

back

Budget constraint: owner, not moving

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

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

back

Budget constraint: owner, moving

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

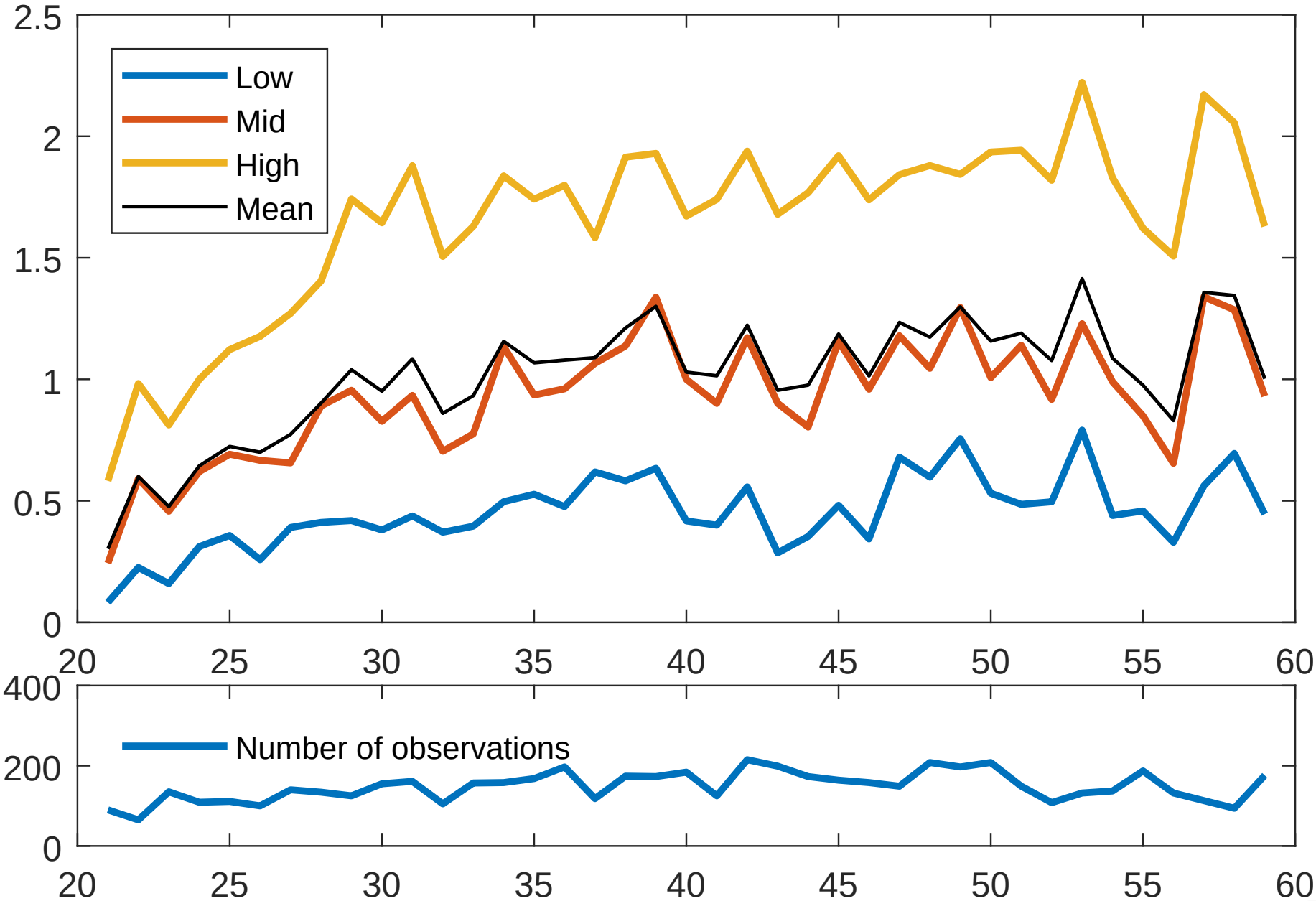
$$\tilde{r} = \begin{cases} r_d & \text{if } B \geq 0 \\ r_c & \text{if } B < 0 \end{cases}$$

if no mortgage default
$B' = \tilde{B}' + (1-t)P_H - (r_m + 1)D - (P_{H'} d + FC_m) \times \mathbb{1}_{H'>0}$
$D' = (1-d)P_{H'} \times \mathbb{1}_{H'>0}$

if mortgage default
$B' = \tilde{B}' + \max\{0,\ (1-t-t_F)P_H - (r_m+1)D\}$
$D' = 0$

back

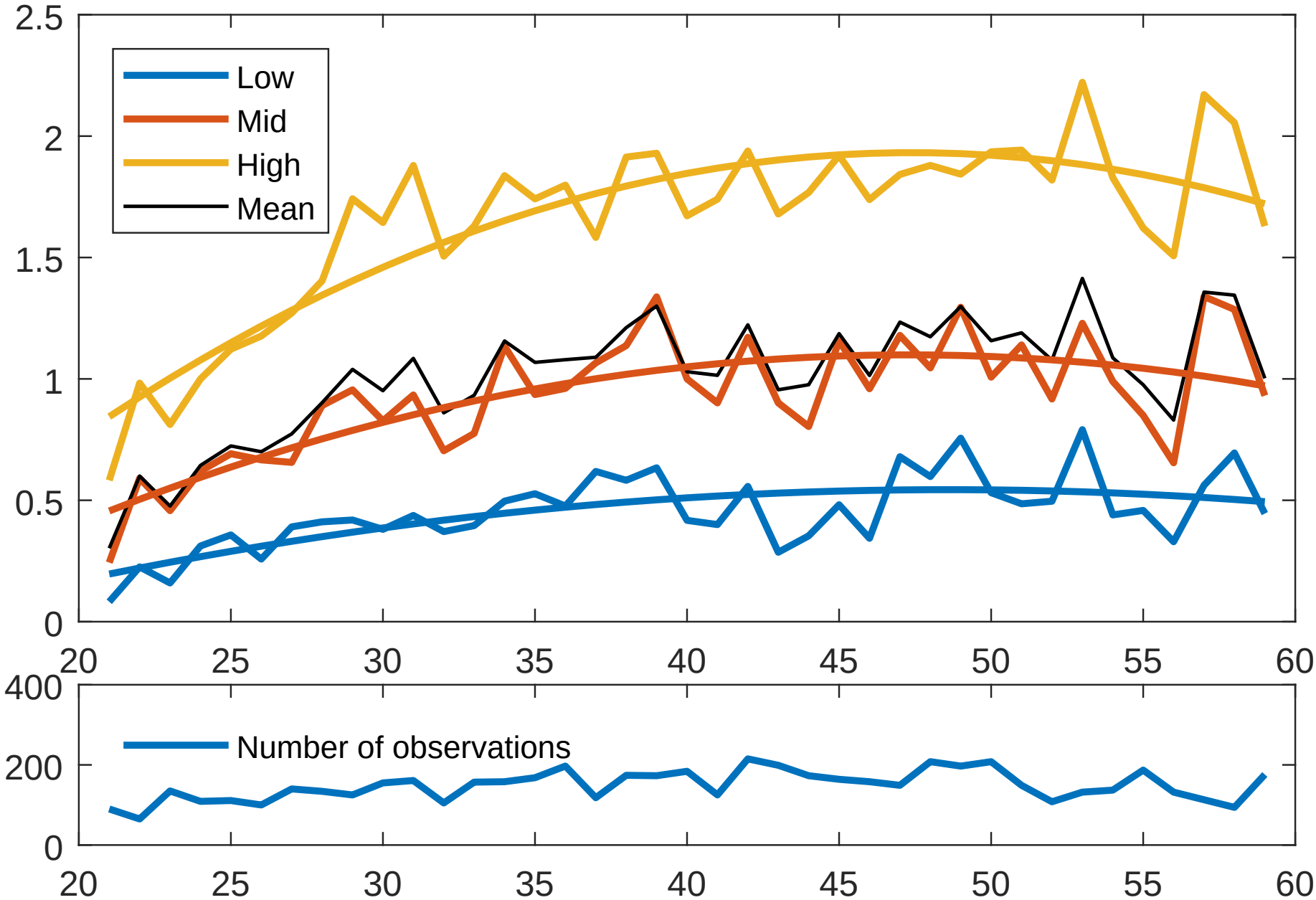
Lifecycle income profile: data



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

back

Lifecycle income profile: model



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

back

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 $\sim$ 500 laptops

Income process

Parameters

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

Income loss from unemployment, %

	Short-term (2 years)		Long-term (10 years)	
	Boom	Bust	Boom	Bust
3+ years tenure, Data	20	30	10	20
3+ years tenure, Model	18	27	12	17
1-2 years tenure, Model	9	20	5	9
Average job loser, Model	14	24	9	14

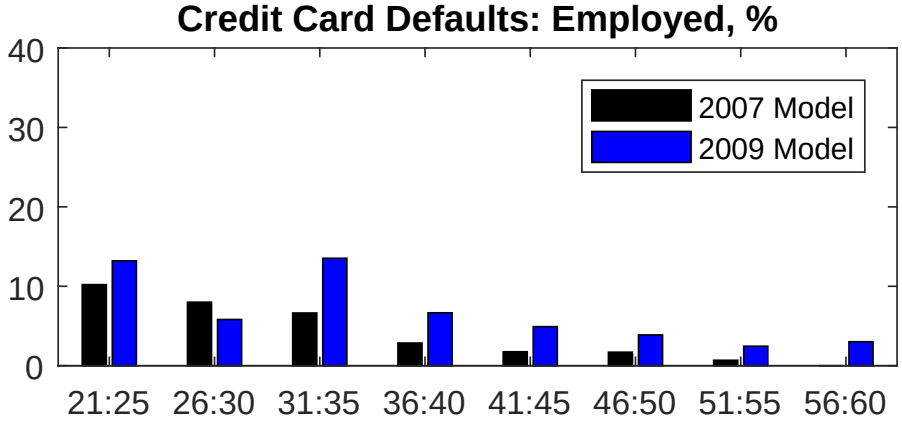
back

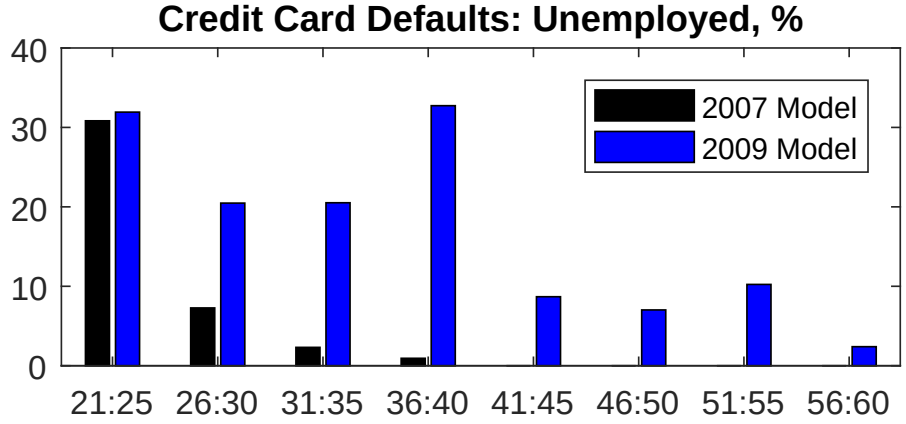
Finance and housing

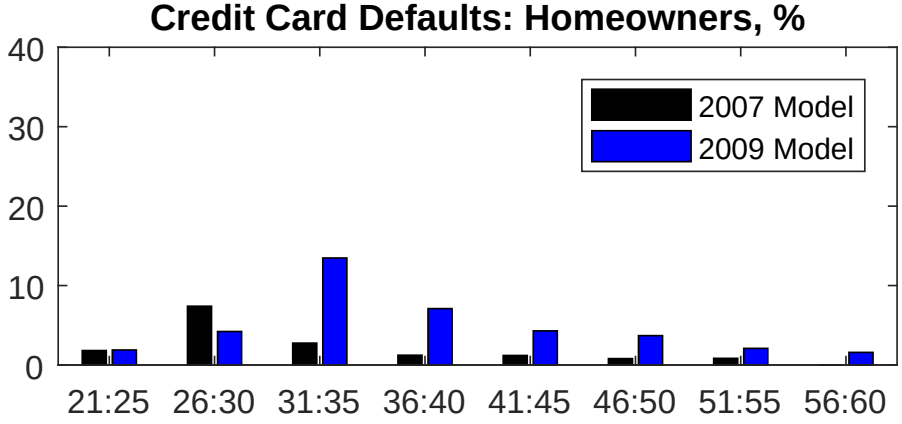
Parameter		Value	Source / Target
deposit	interest rate	-2.7% → -1.7%	Fed
mortgage	downpayment	12% → 18%	Freddie Mae
	payment/income	50% → 40%	Greenwald (2016)
	amortization	1/30 → 1/25	term $\approx 1/\delta$
	origination cost	\$1700	standard
	foreclosure cost	10%	standard
	interest rate	3.6%	Fed
heloc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

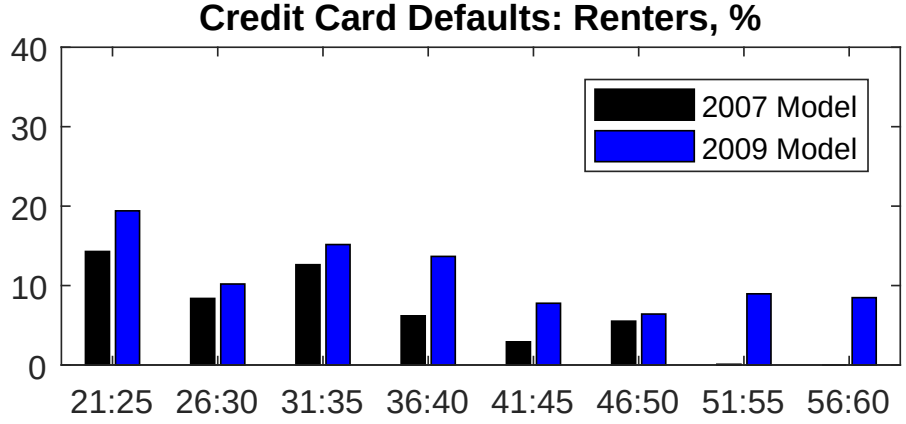
back

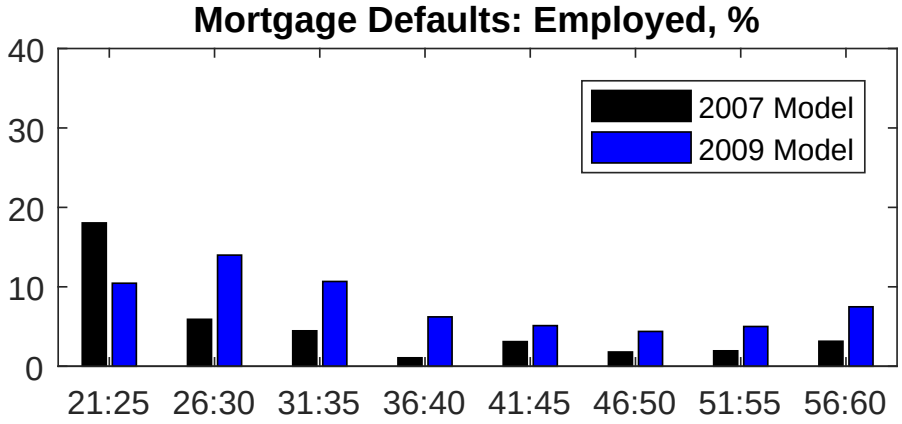
Model outcomes

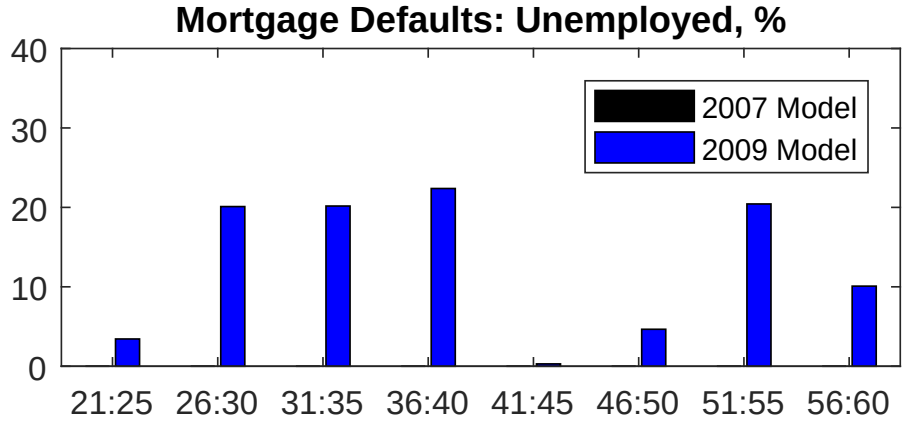












Results: model vs data

	Delinq. rate, %		Networth		House Price/Drop		
	Cr.card	Mort	Non-H	H	Small	Large	Mean
Model Boom	4.1	3.0	19.4	56	151	267	209
Data 2007	4.0	2.7		58	149	264	206
Model Bust	7.2	7.5	20.2	35	32%	21%	25%
Data 2009	6.8	8.6	19.8	39	15%	15%	15%
Data 2012	2.9	10.4			33%	29%	31%

back

Results: subsidy, unemployment, moving shock

	Delinq. rate, %		Networth		House Price/Drop		
	Cr.card	Mort	Non-H	H	Small	Large	Mean
Model 2007	4.1	3.0	19.4	56	151	267	209
Data 2007	4.0	2.7		58	149	264	206
Model 2009	7.2	7.5	20.2	35	32%	21%	25%
Data 2009	6.8	8.6	19.8	39	15%	15%	15%
Data 2012	2.9	10.4			33%	29%	31%
No subsidy	8.9	11.0			42%	29%	34%
No unemployment							
Model 2007	3.8	2.0			159	280	219
Model 2009	5.8	4.9			22%	13%	16%
No moving shock, moving cost unchanged							
Model 2007	3.7	0.7			198	369	283
Model 2009	3.9	3.2			11%	10%	11%
No moving shock, moving cost adjusted							
Model 2007	3.6	0.8			217	440	329
Model 2009	5.8	2.4			8%	14%	12%

back

Mechanisms

High unemployment rate → lower expected future labor income

1. Longer unemployment duration
2. Lower job quality
3. Lower job security

✓ Lower housing demand of employed as well!

Credit conditions & policy

- Tighter mortgage limits → housing less affordable
- Mortgage policy targets annual payment
  - ✓ raises housing demand even of those who don't receive help

Importance of moving shocks

- Existing bust literature: moving for economic reasons only
- This paper: move for non-economic reasons as well
  1. making decisions today, have to consider prob to move in future
  2. less selection (more movers are credit constrained)

  → amplified effect of credit conditions & unemployment

Moving shock

Moving reasons (SCF)
shock: health, married/divorced, change jobs...
engogenous: foreclosure/short sale, rent/cost too high,..

mean moving rate 13%: owners 5% total = 3% exo + 2% endo
renters 30% total = 19% exo + 11% endo

Moving parameters

- population averages by age $P_{move}(age)$: US Census Bureau
- share of moves for external reasons: SCF2007-9 panel
- Moving cost: 16% utility (mean total moving rate 13%)(8% exo)

Quantitative implementation: housing

three types of parameters

1. external constant (black)
2. external changing over Boom/Bust (blue)
3. internal constant, target a moment in Boom (green)

- Utility

  Cobb-Douglas weight on housing $\alpha = .2$

  housing services: $(7.9, 94)$ (Target prices in 2007)

- Costs

  rental rate $p = \$10,000$ per year (US average)

  maintenance cost + property tax $= 2\%$

  housing transaction cost: $6\% \to 9\%$ (illiquidity)

Quantitative implementation: labor income

3 types of parameters
constant over Boom/Bust: external (black), calibrated (green)
changing over Boom/Bust: external (blue)

- work for 40 years, retired for 20 years,
  pension: half liquid (1/2 SCF retirement savings) +
  half frozen/PAYG (22.5% of terminal human capital)
- human capital: SCF 2007 labor income, 3 equal groups
- transitory shock std: 20% (Storesletten, Telmer, Yaron 2004)
- consequences of unemployment (Davis and von Wachter 2011: bold font)
  - benefit: quarterly $\mathbf{z = 0.5}$, annualized $z = 0.7 \to 0.5$
  - transition prob $P_{up} = \mathbf{.08}, P_{down} = \mathbf{.35}$
  - separation rate $s = (\mathbf{.12}, .06, \mathbf{.03})$ (mid s: Shimer 2012)
  - job finding rates: $(f, f_{LTU}) = (.75, .55) \to (.55, .25)$
  - risk of long term U: $p_{LTU} = .05 \to .15$
    BLS, Kosanovich and Sherman (2015)
- income tax 20%

Quantitative implementation: housing

- Utility

  Cobb-Douglas weight on housing $\alpha = .2$

  housing services: $(7.9, 94)$ (Target prices in 2007)
- Moving

  population averages by age: US Census Bureau

  share of moves for external reasons: SCF2007-9 panel

  mean moving rate 13%: owners 5% total = 3% exo + 2% endo

  renters 30% total = 19% exo + 11% endo

  Moving cost: 16% utility (mean total moving rate 13%)
- Costs

  rental rate $p = \$10,000$ per year

  maintenance cost + property tax = 2%

  housing transaction cost: 6% $\rightarrow$ 9% (illiquidity)
- Expected house price growth (CST2012): same for $P_{1,2}$

  6.6% $\rightarrow$ 0 (if stay in Bust) or 20% (if recovery)

  prob of recovery: 25% $\Rightarrow$ mean growth in Bust: 5%

Quantitative implementation: finance

- Mortgage

  downpayment: 12% → 18%

  payment to income ratio: .5 → .4

  subsidy: 40% pay if .31 < pay/inc < .52 & $W_{Low,\,Mid}$
  44% households aware (HAMP data)

  amortization rate: 1/30 → 1/25 (fewer backloaded m)

  foreclosure cost: 10% price + 0.5% utility (defaults 2007)

  origination cost: \$1700
- Heloc

  (mortgage + HELOC) to house value: .85 → .60

  fixed cost: \$100 (Corelogic'16)
- Credit card

  debt to income ratio 1 → .8

  default cost 37% utility (defaults 2007)
- interest rates, %: Deposit, Mortgage, HELOC, Credit Card
  $(r_d, r_m, r_h, r_c) = (-2.7, 3.6, 5.3, 10.4) \to (-1.7, 3.6, 1.6, 11.6)$

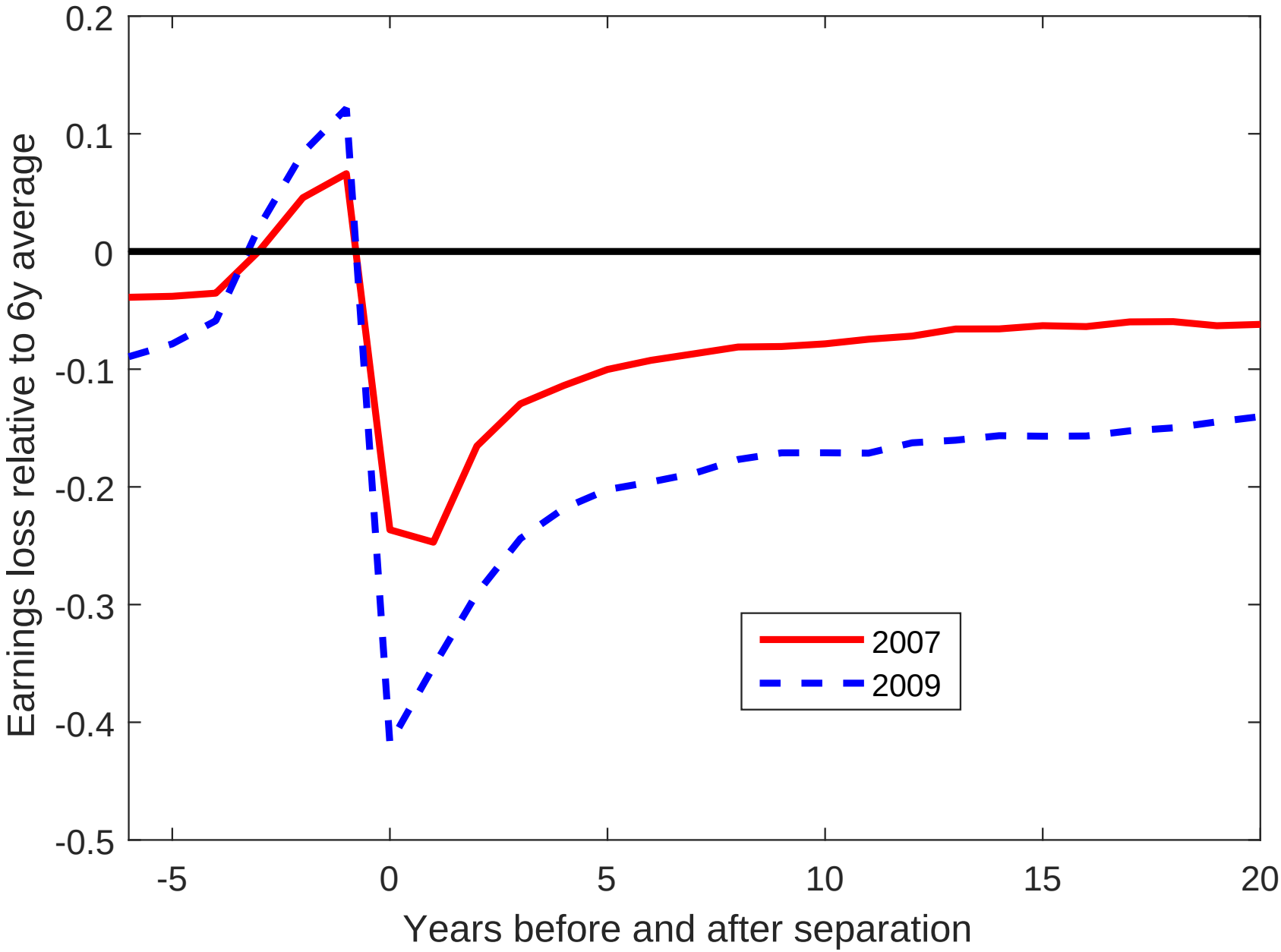
Quantitative implementation: other parameters

- Share of pension savings available: .5 (robustness: .25–.75)
- Discount $\beta = .91$ (savings choice in 2007)
- Risk aversion $\gamma = 2$
- Aggregate state transition probabilities

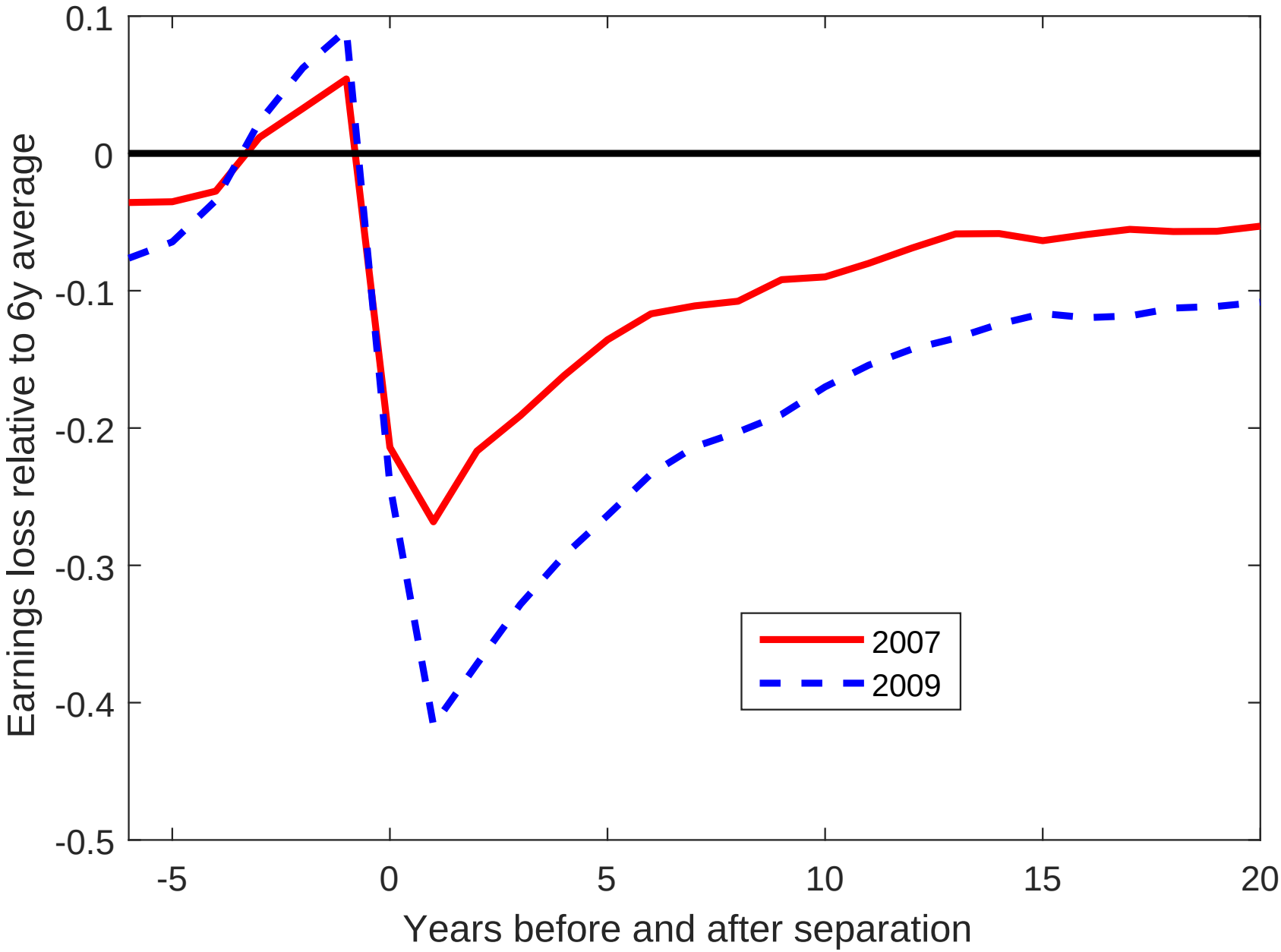
  Bust $\rightarrow$ Boom: 0 (robustness: 0–.1)

  Boom $\rightarrow$ Bust: .2475 (tied to expected house price growth, assuming house prices go up by 20% if transition to Boom, robustness: 10%-30%)
- Distribution of agents (age, income, assets, liabilities, employment, homeownership): SCF'2007 $\rightarrow$ SCF'2009
  bottom 90% by income, only labor force

Income process: model (quarterly)



Income process: model (annual)



Bellman equations for employed homeowners

Note: simplified version of model

$$
\begin{aligned}
V_{eo}(B,D,w) = & \max_{C\geq 0,\ B'\geq -\bar{B}_i w,\ H'\in\{0;1\}} \frac{C^{1-\gamma}}{1-\gamma} + F \\
& + \beta(1-H)\Big\{(1-s)\mathbb{E}V_{er}[B',w'] + s\mathbb{E}V_{ur}[B',w']\Big\} + \\
& + \beta H\Big\{(1-s)\mathbb{E}V_{eo}[B',w',(1-\delta)D] \\
& + s\mathbb{E}V_{uo}[B',w',(1-\delta)D]\Big\} \\
B' = & (1+r_i)B + w - h - C + (1-\tau)P - (1+r_m)D, H' = 0 \\
B' = & (1+r_i)B + w - C - (r_m+\delta)D, \quad H' = 1
\end{aligned}
$$

Bellman equations for unemployed homeowners

Note: simplified version of model

$$
\begin{aligned}
V_{uo}(B,D,w) = & \max_{C\geq 0, B'\geq 0, H'\in\{0;1\}} \frac{C^{1-\gamma}}{1-\gamma} + F \\
& + \beta(1-H)\Big\{ f_i \mathbb{E}V_{er}[B',w'] + (1-f_i)\mathbb{E}V_{ur}[B',w'] \Big\} + \\
& + \beta H \Big\{ f_i \mathbb{E}V_{eo}[B',w',(1-\delta)D] \\
& + (1-f_i)\mathbb{E}V_{uo}[B',w',(1-\delta)D] \Big\} \\
B' = & (1+r_i)B + zw - h - C + (1-\tau)P - (1+r_m)D, H' = 0 \\
B' = & (1+r_i)B + zw - C - (r_m+\delta)D, \quad H' = 1
\end{aligned}
$$

Bellman equations for renters

Note: simplified version of model

$$
\begin{aligned}
V_{er}(B,w) = & \max_{C\geq 0,\ B'\geq -\bar{B}_i w,\ H'\in\{0;1\}} \frac{C^{1-\gamma}}{1-\gamma} + \\
& + \beta(1-H)\Big\{(1-s)\mathbb{E}V_{er}[B',w'] + s\mathbb{E}V_{ur}[B']\Big\} + \\
& + \beta H\Big\{(1-s)\mathbb{E}V_{eo}[B',w',(1-d)P] + s\mathbb{E}V_{uo}[B',(1-d)P]\Big\} \\
B' = & (1+r_i)B + w - h - C - dP\times H' \\
V_{ur}(B,w) = & \max_{C\geq 0,B'\geq 0,H'\in\{0;1\}} \frac{C^{1-\gamma}}{1-\gamma} + \\
& + \beta(1-H)\Big\{f_i\mathbb{E}V_{er}[B',w'] + (1-f_i)\mathbb{E}V_{ur}[B',w']\Big\} + \\
& + \beta H\Big\{f_i\mathbb{E}V_{eo}[B',w',(1-d)P] + (1-f_i)\mathbb{E}V_{uo}[B',(1-d)P]\Big\} \\
B' = & (1+r_i)B + zw - h - C - dP\times H'
\end{aligned}
$$

Model overview

Lifecycle model with incomplete markets & heterogeneous agents

Individual household problem

- lifecycle consumption-savings choice, rent vs own houses
- borrow using credit cards, mortgages, home equity lines of credit

Aggregate economy

- business cycle driven by 2-state Markov chain: boom and bust
- equilibrium house prices clear markets given fixed supply

Quantitative exercise overview

Exercise 2007

- start in boom state and 2007 SCF distribution of households
- choose preference parameters to match aggregates in 2007
- result: match untargeted x-section of households' choices by age

Exercise 2009

- start in bust state and 2009 distribution
- keep preference parameters fixed, no moments targeted
- result: match house price drop, mortgage & credit card delinquencies
- decomposition
  - ⋆ large effect: credit constraints on mortgages, job finding rates
  - ⋆ small effect: expectations, heloc limits

Overview

Lifecycle model with incomplete markets & heterogeneous agents

Individual household problem

- lifecycle consumption-savings choice, rent vs own houses
- borrow using credit cards, mortgages, home equity lines of credit

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- business cycle driven by 2-state Markov chain: boom and bust
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Quantitative exercise

Start in boom and 2007 SCF distribution of households

- choose preference parameters to match aggregates in 2007
- result: match x-section of households' choices by age

Start in bust and 2009 distribution, no moments targeted

- result: match house price drop, mortgage & credit card delinquencies
- decomposition