

# Financial Fragility with SAM?

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BI-SHOF Annual Conference  
June 4, 2018

# Motivation

- ▶ Standard mortgage contracts share house price risk in a particular way
  - Borrower bears all house price risk until default
  - Lender bears tail risk when house prices fall enough to trigger default

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- ▶ Foreclosure crisis called into question this risk-sharing arrangement
- ▶ Led economists to propose alternative risk-sharing arrangements
  - Popular proposal: Shared Appreciation Mortgage (SAM)
  - Payments fall if house price declines, staving off foreclosures
  - Lender receives share of the upside upon sale

# Motivation

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- ▶ Foreclosure crisis called into question this risk-sharing arrangement
- ▶ Led economists to propose alternative risk-sharing arrangements
- ▶ But is it safe to shift house price losses to lenders?
  - Banks and credit unions hold \$5.5T in mortgage debt on balance sheets
  - Large undiversifiable component to house price risk
  - Losses inflicted at times when banks may be fragile already
  - Offset by improved risk sharing/reduced defaults? Need GE model.

# This Paper

- ▶ **Question:** how do Shared Appreciation Mortgage (SAM) contracts influence financial stability and risk sharing?
- ▶ **Approach:** build GE model of mortgage and housing market with explicit financial sector to intermediate between borrowers and savers.
  - Start from realistic mortgage debt contracts: long-term, nominal, prepayable, defaultable
  - Consider different forms of mortgage payment indexation (SAMs)
- ▶ **Main insights:**
  1. Indexing to **aggregate** house prices **increases** financial fragility
  2. Indexing to **relative local** prices can **dampen** fragility
  3. Schemes that help risk sharing often hurt financial sector profits

# This Paper

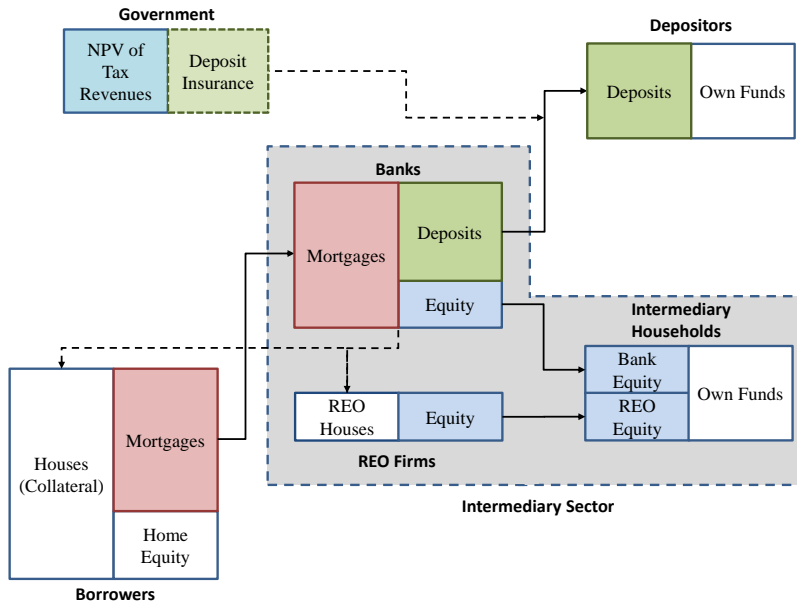
- ▶ **Question:** how do Shared Appreciation Mortgage (SAM) contracts influence financial stability and risk sharing?
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  - Start from realistic mortgage debt contracts: long-term, nominal, prepayable, defaultable
  - Consider different forms of mortgage payment indexation (SAMs)
- ▶ **Policy conclusion:** only carefully designed mortgage indexation leads to aggregate stability and risk-sharing benefits.
  - Commonly proposed features like asymmetric and interest-only adjustment have important macro consequences.

## Related Literature

- ▶ Asset pricing models with financial intermediaries:
  - Brunnermeier + Sannikov 14, 15, 17, Gârleanu + Pedersen 11, Gertler + Karadi 11, He + Krishnamurthy 12, 13, 15, Adrian + Boyarchenko 12, Savov + Moreira 16
  - **Contribution:** split banks and borrowers, risk sharing with multiple contract types
- ▶ Quantitative macro models of mortgage markets:
  - Favilukis, Ludvigson, Van Nieuwerburgh 17, Corbae + Quintin 14, Elenev, Landvoigt, Van Nieuwerburgh 16, Landvoigt 15, Garriga, Kydland, Sustek 15, Greenwald 16, Wong 15
  - **Contribution:** realistic mortgages and intermediation in GE
- ▶ Alternative mortgage contracts/SAMs:
  - Eberly + Krishnamurthy 14, Hall 15, Kung 15, Mian 13, Mian + Sufi 14, Piskorski + Tchisty 17, Guren, Krishnamurthy, McQuade 17
  - **Contribution:** effect on risk sharing, housing/mortgage markets with levered intermediaries



# Model Overview



# Demographics, Endowments, Preferences

## ▶ Demographics

- Three types of agents: Borrowers, Depositors, Intermediaries
- Population mass  $\chi_j$  for  $j \in \{B, D, I\}$
- Perfect consumption insurance within, but not across types (aggregation).

## ▶ Endowments

## ▶ Preferences

# Demographics, Endowments, Preferences

## ▶ Demographics

## ▶ Endowments

- Non-durable endowment, income shock:

$$\log Y_t = (1 - \rho_y) \log \bar{Y} + \rho_y \log Y_{t-1} + \sigma_y \varepsilon_{y,t}, \quad \varepsilon_{y,t} \sim N(0, 1)$$

- Agent  $j \in \{B, D, I\}$  receives share  $s_j$  of  $Y_t$ , taxed at rate  $\tau$ .
- Housing tree provides services in fixed supply ( $\bar{K} = H_t^B + H_t^D + H_t^I$ ).

## ▶ Preferences

# Demographics, Endowments, Preferences

- ▶ Demographics
- ▶ Endowments
- ▶ Preferences

- Epstein-Zin:

$$U_t^j = \left\{ (1 - \beta_j) (u_t^j)^{1-1/\psi} + \beta_j \left( \mathbb{E}_t \left[ (U_{t+1}^j)^{1-\gamma_j} \right] \right)^{\frac{1-1/\psi}{1-\gamma_j}} \right\}^{\frac{1}{1-1/\psi}}$$
$$u_t^j = (C_t^j)^{1-\zeta_t} (H_t^j)^{\zeta_t}$$

- Borrowers, intermediaries more impatient:  $\beta_b = \beta_i < \beta_d$
- Fixed intermediary/depositor housing demand:  $H_t^I = \bar{K}^I, H_t^D = \bar{K}^D$ .
- **Housing demand** shock  $\zeta_t$ .

# Mortgage Contract

- ▶ Mortgages are geometric perpetuities with duration parameter  $\delta$
- ▶ Example: borrow face value  $M_0$  at rate  $r_0^*$  at  $t = 0$ 
  - Each period, pay off  $1 - \delta$  of principal,  $M_{t+1} = \delta M_t$ .
  - Fixed rate: interest payment of  $r_0^* M_t$  in each period (tax deductible).
- ▶ Costly debt renewal at endogenous rate
  - Renewers choose new mortgage balance  $M_t^*$  and house size  $K_t^*$ , subject to borrowing constraint at origination:  $M_t^* \leq \phi^K p_t K_t^*$ .
- ▶ Default and foreclosure
  - Indiv. borrowers draw idiosyncratic house value shocks  $\omega_{i,t} \stackrel{iid}{\sim} \Gamma_{\omega,t}$ .  
Endogenous fraction with worst shocks default.

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# Idiosyncratic Shocks and Mortgage Default

- ▶ At start of  $t$ , all borrowers have housing capital  $K_t^B$ , debt  $(M_t^B, A_t^B)$
- ▶ Draw idiosyncratic/local home valuation shock  $\omega_{i,t} \stackrel{iid}{\sim} \Gamma_{\omega,t}$ .
  - Local (insurable) component  $(\omega_{i,t}^L)$  + uninsurable indiv. component  $(\omega_{i,t}^U)$ :

$$\log \omega_{i,t} = \log \omega_{i,t}^L + \log \omega_{i,t}^U$$

- Constant local share of variation ( $\alpha$ ), time-varying XS variance:

$$\text{Var}_t(\log \omega_{i,t}^L) = \alpha \sigma_{\omega,t}^2 \qquad \text{Var}_t(\log \omega_{i,t}^U) = (1 - \alpha) \sigma_{\omega,t}^2$$

- ▶ Borrowers with  $\omega_{i,t} < \bar{\omega}_t$  optimally default. Banks seize housing capital and erase debt of defaulting borrowers.
  - Default rate:  $Z_{D,t} = \Gamma_{\omega,t}(\bar{\omega}_t)$ .
  - Frac. housing retained:  $Z_{K,t} = \int_{\omega_{i,t} > \bar{\omega}_t} \omega_{i,t} d\Gamma_{\omega,t}$ .



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# Mortgage Contract: Summary

- ▶ State variables for borrower: principal balance ( $M_t^B$ ), promised interest payment ( $A_t^B$ ), borrower-owned housing ( $K_t^B$ ).
  1. Costly debt **renewal** at endog. rate  $Z_{R,t}$ .
  2. **Default** and foreclosure at endog. rate  $Z_{D,t}$ .
- ▶ Transition laws:

$$\begin{aligned}M_{t+1}^B &= \bar{\pi}^{-1} \left[ Z_{R,t}(1 - Z_{D,t})M_t^* + \delta(1 - Z_{R,t})(1 - Z_{D,t})M_t^B \right] \\A_{t+1}^B &= \bar{\pi}^{-1} \left[ Z_{R,t}(1 - Z_{D,t})r_t^*M_t^* + \delta(1 - Z_{R,t})(1 - Z_{D,t})A_t^B \right] \\K_{t+1}^B &= Z_{R,t}(1 - Z_{D,t})K_t^* + (1 - Z_{R,t})Z_{K,t}K_t^B\end{aligned}$$

## Indexation: Basics

- ▶ Define a borrower's initial leverage as  $\lambda = M/p\omega K$ , where  $p$  is national house price, and  $\omega$  is relative value of individual house.
- ▶ Housing wealth hit by two forces that shift leverage:

$$p\omega K \rightarrow \left(\frac{p'}{p}\right) \cdot \left(\frac{\omega'}{\omega}\right) \cdot p\omega K, \quad \lambda' = \left(\frac{1}{p'/p}\right) \cdot \left(\frac{1}{\omega'/\omega}\right) \lambda$$

for idiosyncratic shock  $\omega$ .

- ▶ Indexation scales mortgage debt, dampening shocks to leverage:

$$M \rightarrow \zeta_p \cdot \zeta_\omega \cdot M, \quad \lambda' = \left(\frac{\zeta_p}{p'/p}\right) \cdot \left(\frac{\zeta_\omega}{\omega'/\omega}\right) \lambda$$

- ▶ Full indexation ( $\zeta_p = p'/p$ ,  $\zeta_\omega = \omega'/\omega$ ) implies  $\lambda' = \lambda$ .

# Indexation: Implementation

- ▶ **SAM:** index by scaling both principal balance and payment

1. Aggregate:  $\zeta_{p,t} = \frac{p_t}{p_{t-1}}$

2. Individual/local:  $\zeta\omega(\omega_{i,t}) = \frac{\omega_{i,t}^L}{\omega_{i,t-1}^L}$

- ▶ Transition laws:

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- ▶ Default threshold (“Q” terms are average continuation values/costs):

$$\bar{\omega}_{i,t}^U = \frac{1}{\omega_{i,t}^L} \cdot \frac{Q_{A,t}A_t + Q_{M,t}M_t}{Q_{K,t}K_t^B}$$

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# Borrowers

- ▶ Perfect sharing of nondurable consumption and housing services risk *within* borrower family  $\implies$  aggregation.
- ▶ Representative borrower chooses
  - housing and non-housing consumption
  - refinancing rate
  - for refinancers only:  $\left\{ \begin{array}{l} \text{new mortgage balance} \\ \text{new housing purchases} \end{array} \right.$
  - default rate

to maximize utility subject to budget constraint and loan-to-value constraint on **new** borrowing

# Intermediaries

- ▶ Intermediary sector consists of **banks, REO firms, and households**
- ▶ Intermediary **households** receive endowment income and hold equity of banks and REO firms
- ▶ **Banks** maximize SHV, pay dividends to intermediary households
- ▶ Limited liability and deposit insurance s.t. capital requirement
- ▶ **REO firms** maximize SHV, pay dividends to intermediary households

▶ Complete Problem



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- ▶ **Banks** maximize SHV, pay dividends to intermediary households
  - Issue new loans to borrowers
  - Take deposits from depositors
  - Seize foreclosed properties and sell to REO firms at price  $p_t^{REO} < p_t$
  - Trade mortgages on the secondary market (IO + PO strips)
- ▶ Limited liability and deposit insurance s.t. capital requirement
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- ▶ **Banks** maximize SHV, pay dividends to intermediary households
- ▶ Limited liability and deposit insurance s.t. capital requirement
  - Receive idiosyncratic profit shocks and optimally default
  - Government assumes all assets and liabilities of defaulting banks
  - Fraction  $\eta$  of bankrupt banks' assets are DWL to society
  - Capital requirement:

$$\text{deposits} \leq \phi^I (\text{MV of mortgage securities})$$

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- ▶ Limited liability and deposit insurance s.t. capital requirement
- ▶ **REO firms** maximize SHV, pay dividends to intermediary households
  - Buy foreclosed houses from banks
  - Maintain REO housing stock ( $v^{REO} > v$ )
  - Rent current REO stock to borrowers
  - Slowly sell REO properties back to borrowers

▶ Complete Problem

# Depositors and Government

## Depositors:

- ▶ More patient than borrowers and intermediaries
- ▶ Only invest in deposits

## Government:

- ▶ Discretionary spending from income tax net of mortgage deduction
- ▶ Funds fraction  $\tau_L$  of deposit shortfall of failing banks through lump-sum taxation, the remainder by issuing debt

$$q_t^f B_{t+1}^G = (1 - \tau_L) (B_t^G + \text{bailout}_t)$$

- ▶ Benchmark case: immediate full taxation ( $\tau_L = 1, B_t^G = 0 \forall t$ )
- ▶ Results robust to partial debt funding with  $\tau_L < 1$

# Equilibrium

- ▶ Given prices and parameters, three households, banks, and REO firms maximize their value functions subject to budget and borrowing constraints
- ▶ Markets clear
  - ▶ New mortgages ( $\rightarrow$  mortgage rate)
  - ▶ Secondary mortgage market ( $\rightarrow$  mortgage bond price)
  - ▶ Housing purchases ( $\rightarrow$  house price)
  - ▶ REO purchases ( $\rightarrow$  REO house price)
  - ▶ Housing services ( $\rightarrow$  rental rate)
  - ▶ Deposits and government debt ( $\rightarrow$  riskfree rate)
- ▶ Resource constraint

$$Y_t = \text{CONS}_t + \text{GOV}_t + \underbrace{v^K p_t (\bar{K} - K_t^{\text{REO}})}_{\text{regular housing maint.}} + \underbrace{v^{\text{REO}} p_t K_t^{\text{REO}}}_{\text{REO housing maint.}} + \underbrace{DWL_t}_{\text{bank failures}}$$

# State Variables and Solution Method

- ▶ Exogenous states
  - Persistent aggregate **income**  $Y_t$ , discretized
  - Persistent disp. of idio. housing (**uncertainty**) shock:  $\sigma_{\omega,t}$
  - Persistent housing (**demand**) shock:  $\xi_t$
- ▶ Six endogenous states: housing stock, mortgage principal, mortgage payments, deposits, intermediary wealth, government debt
  - Wealth distribution matters for asset prices due to incomplete markets
  - Intermediary wealth is a key state variable
- ▶ Nonlinear global solution method: policy time iteration
  - Risk premia have important implications for welfare results
  - Occasionally binding intermediary constraint
  - Non-linear dynamics when intermediaries are constrained

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# Calibration

- ▶ Quarterly calibration targeting sample 1991.Q1 - 2016.Q1
  1. Demographics (pop., income) from 1998 SCF
    - “Borrower” is mortgagor with  $LTV \geq 30\%$  (hold 89% of debt).
    - Intermediary income based on FIRE sector.
  2. Exogenous shocks
  3. Mortgage debt: realistic calibration of prepayment and credit risk
  4. Banks: match average FDIC bank failure rate, receivership costs
  5. Preferences: EZ utility with EIS 1

▶ All parameters

# Calibration

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  1. Demographics (pop., income) from 1998 SCF
  2. Exogenous shocks
    - **Income:** AR(1), match detrended labor income persistence, vol.
    - **Uncertainty:** two regimes, transition probs match fraction of time in foreclosure crisis, vols to match conditional default rates.
    - **Housing demand:** same two regimes, match average expenditure share, house price vol.
  3. Mortgage debt: realistic calibration of prepayment and credit risk
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  2. Exogenous shocks
  3. Mortgage debt: realistic calibration of prepayment and credit risk
    - Choose renewal cost parameters following Greenwald (2018)
    - Max LTV at origination 85%
    - REO maint.  $\nu^{REO}$  to match loss given default on mortgages of 40%
  4. Banks: match average FDIC bank failure rate, receivership costs
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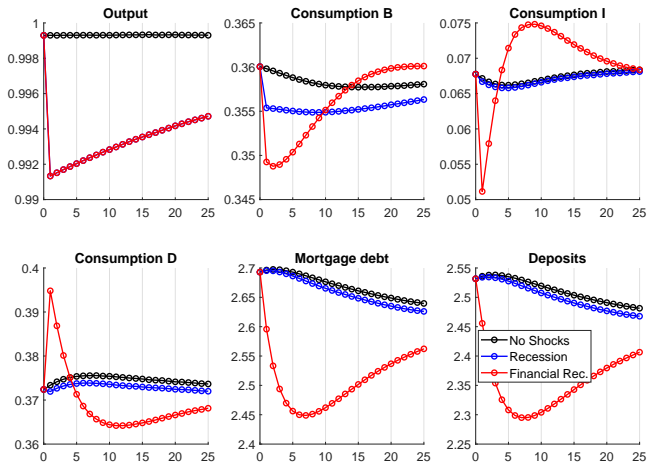
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  5. Preferences: EZ utility with EIS 1
    - $\beta_B = \beta_I = 0.95$ : match borrower VTI
    - $\beta_S = 0.998$ : mean  $r^f$  of 3% (ann.)
    - $\gamma = 5$ : standard value

▶ All parameters

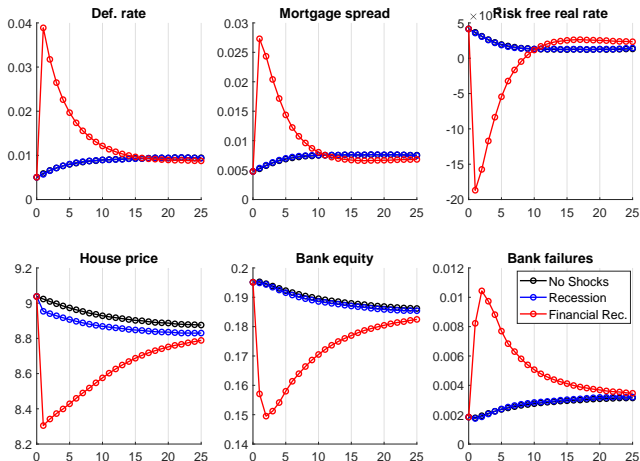
# Financial Recession: Allocations

- ▶ Consumption shifts from  $B, I \rightarrow D$  as financial sector contracts.



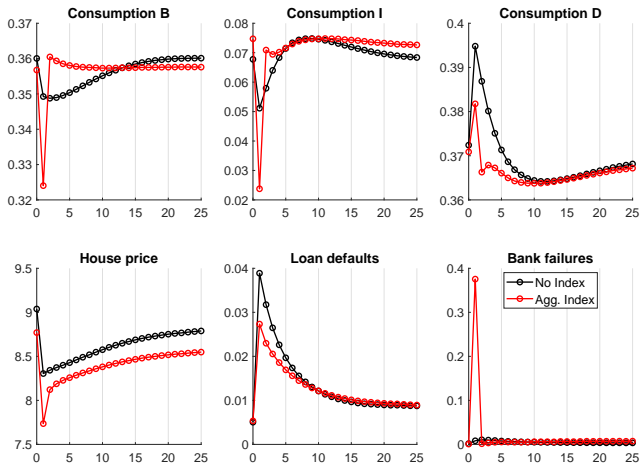
# Financial Recession: Prices and Defaults

- ▶ Drop in house prices and short rate, spreads + defaults up.
- ▶ Sharp reduction in bank equity and spike in bank failures



# Aggregate Indexation: Financial Fragility

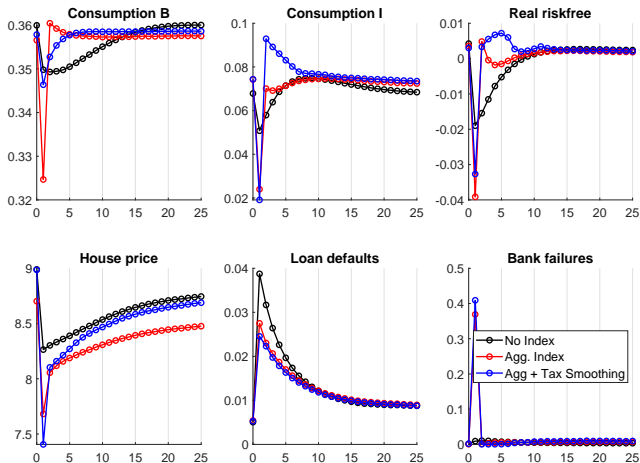
- ▶ Comparison: baseline vs. full aggregate indexation ( $\zeta_p = p' / p$ )
- ▶ Foreclosures  $\downarrow$  (indiscriminate debt relief), bank failures  $\uparrow\uparrow$ .





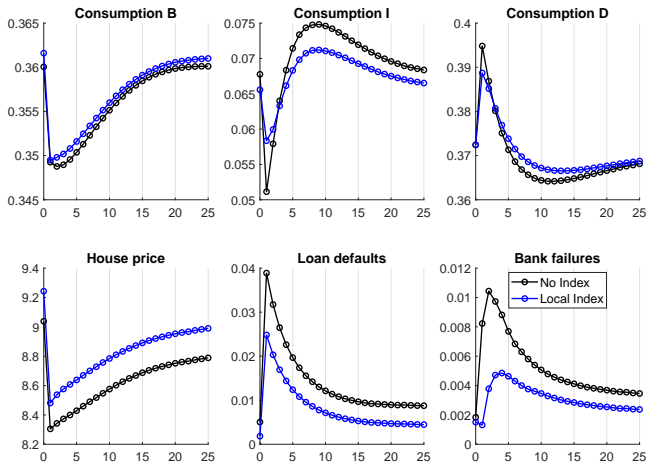
# Aggregate Indexation: Financial Fragility

- ▶ Immediate financing of bailouts  $\implies$  sharp consumption drops.
- ▶ Would tax smoothing help? No! Gov't debt crowds out deposits.



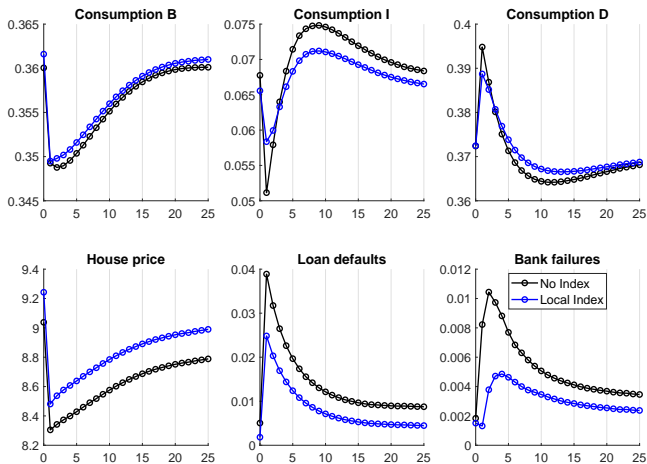
# Local Indexation: Financial Stability

- ▶ Comparison: baseline vs. full local indexation ( $\zeta_\omega = \omega'_L / \omega_L$ )
- ▶ Local share of variance ( $\alpha$ ): 25%.



# Local Indexation: Financial Stability

- ▶ Foreclosures  $\downarrow\downarrow$  (targeted debt relief)
- ▶ Bank failures  $\downarrow\downarrow$ , financial fragility reduced



# Model Moments by Indexation Regime (Quarterly)

- ▶ Regional model: indexation at aggregate and local levels.

	No Index	Aggregate	Local Only	Regional
Mortgage default rate	0.95%	0.92%	0.49%	0.47%
Bank equity ratio	7.09%	7.33%	7.13%	7.25%
Fraction leverage constr. binds	99.35%	90.16%	99.90%	90.92%
Bank failure rate	0.33%	0.84%	0.22%	0.50%
Mortgage rate	1.46%	1.54%	1.30%	1.35%
Credit spread	0.75%	0.87%	0.56%	0.60%
Mortgage excess return	0.34%	0.49%	0.35%	0.40%
House price	8.842	8.595	9.042	8.784
Mortgage debt	259.59%	252.53%	274.88%	267.74%
Deposits	2.454	2.381	2.599	2.526

# Model Moments by Indexation Regime (Quarterly)

- ▶ Defaults: no indexation > agg. indexation >> local indexation.

	No Index	Aggregate	Local Only	Regional
Mortgage default rate	0.95%	0.92%	0.49%	0.47%
Bank equity ratio	7.09%	7.33%	7.13%	7.25%
Fraction leverage constr. binds	99.35%	90.16%	99.90%	90.92%
Bank failure rate	0.33%	0.84%	0.22%	0.50%
Mortgage rate	1.46%	1.54%	1.30%	1.35%
Credit spread	0.75%	0.87%	0.56%	0.60%
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Mortgage debt	259.59%	252.53%	274.88%	267.74%
Deposits	2.454	2.381	2.599	2.526

# Model Moments by Indexation Regime (Quarterly)

- ▶ Agg. indexation: extra capital insufficient against higher risk.

	No Index	Aggregate	Local Only	Regional
Mortgage default rate	0.95%	0.92%	0.49%	0.47%
Bank equity ratio	7.09%	7.33%	7.13%	7.25%
Fraction leverage constr. binds	99.35%	90.16%	99.90%	90.92%
Bank failure rate	0.33%	0.84%	0.22%	0.50%
Mortgage rate	1.46%	1.54%	1.30%	1.35%
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Deposits	2.454	2.381	2.599	2.526

# Model Moments by Indexation Regime (Quarterly)

- Higher financial fragility  $\implies$  higher spreads, profits.

	No Index	Aggregate	Local Only	Regional
Mortgage default rate	0.95%	0.92%	0.49%	0.47%
Bank equity ratio	7.09%	7.33%	7.13%	7.25%
Fraction leverage constr. binds	99.35%	90.16%	99.90%	90.92%
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Mortgage debt	259.59%	252.53%	274.88%	267.74%
Deposits	2.454	2.381	2.599	2.526

## Model Moments by Indexation Regime (Quarterly)

► Lower risk/rates  $\implies$  higher house prices  $\implies$  debt, deposits  $\uparrow$ .

	No Index	Aggregate	Local Only	Regional
Mortgage default rate	0.95%	0.92%	0.49%	0.47%
Bank equity ratio	7.09%	7.33%	7.13%	7.25%
Fraction leverage constr. binds	99.35%	90.16%	99.90%	90.92%
Bank failure rate	0.33%	0.84%	0.22%	0.50%
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Mortgage debt	259.59%	252.53%	274.88%	267.74%
Deposits	2.454	2.381	2.599	2.526



# Comparing Indexation Regimes: Welfare

- ▶ Agg. indexation: borrowers lose, intermediaries gain!

	No Index	Aggregate	Local Only	Regional
Value function, B	0.379	-0.57%	+0.43%	+0.27%
Value function, D	0.374	-0.07%	+0.07%	+0.47%
Value function, I	0.068	+5.66%	-2.11%	-0.21%
Consumption, B	0.359	-0.3%	+0.3%	+0.1%
Consumption, D	0.372	-0.6%	+0.1%	+0.3%
Consumption, I	0.068	+6.1%	-2.9%	-0.4%
Consumption gr vol, B	0.42%	+351.3%	+15.9%	+189.0%
Consumption gr vol, D	1.11%	-10.4%	-26.5%	-15.4%
Consumption gr vol, I	4.47%	+392.9%	-54.1%	+282.5%
Wealth gr vol, I	0.035	+1366.8%	-1.8%	+679.3%
log (MU B / MU D) vol	0.025	-4.6%	-10.4%	-21.5%
log (MU B / MU I) vol	0.061	+145.7%	-36.8%	+101.8%

## Comparing Indexation Regimes: Welfare

- Higher spreads, bailouts  $\implies$  higher intermediary consumption.

	No Index	Aggregate	Local Only	Regional
Value function, B	0.379	-0.57%	+0.43%	+0.27%
Value function, D	0.374	-0.07%	+0.07%	+0.47%
Value function, I	0.068	+5.66%	-2.11%	-0.21%
Consumption, B	0.359	-0.3%	+0.3%	+0.1%
Consumption, D	0.372	-0.6%	+0.1%	+0.3%
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log (MU B / MU I) vol	0.061	+145.7%	-36.8%	+101.8%

## Comparing Indexation Regimes: Welfare

- ▶ Agg. indexation sharply increases consumption vol for  $B, I$ .

	No Index	Aggregate	Local Only	Regional
Value function, B	0.379	-0.57%	+0.43%	+0.27%
Value function, D	0.374	-0.07%	+0.07%	+0.47%
Value function, I	0.068	+5.66%	-2.11%	-0.21%
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log (MU B / MU D) vol	0.025	-4.6%	-10.4%	-21.5%
log (MU B / MU I) vol	0.061	+145.7%	-36.8%	+101.8%

# Comparing Indexation Regimes: Welfare

- ▶ Improved risk sharing under local indexation.

	No Index	Aggregate	Local Only	Regional
Value function, B	0.379	-0.57%	+0.43%	+0.27%
Value function, D	0.374	-0.07%	+0.07%	+0.47%
Value function, I	0.068	+5.66%	-2.11%	-0.21%
Consumption, B	0.359	-0.3%	+0.3%	+0.1%
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log (MU B / MU D) vol	0.025	-4.6%	-10.4%	-21.5%
log (MU B / MU I) vol	0.061	+145.7%	-36.8%	+101.8%

## Comparison: Alternative Contracts

- ▶ Indexation of interest only (“IO”): effects much weaker since only last until next renewal.

	No Index	Regional	Reg. IO	Reg. Asym.
Deposits	2.454	2.526	2.484	2.196
House Price	8.842	8.784	8.806	8.488
Mortgage Debt	259.59%	267.74%	261.60%	231.85%
Mortgage Rate	1.46%	1.35%	1.41%	2.37%
Refi Rate	3.84%	3.74%	3.84%	4.42%
Default Rate	0.95%	0.47%	0.80%	0.12%
Bank Failure Rate	0.33%	0.50%	0.30%	0.94%
Value Function, B	0.379	+0.27%	+0.30%	+1.85%
Value Function, D	0.374	+0.47%	+0.25%	+0.07%
Value Function, I	0.068	-0.21%	-0.61%	-1.91%

## Comparison: Alternative Contracts

- ▶ Asymmetric indexation where payments can only fall (“Asym”): increases financial fragility, shrinks mortgage balances

	No Index	Regional	Reg. IO	Reg. Asym.
Deposits	2.454	2.526	2.484	2.196
House Price	8.842	8.784	8.806	8.488
Mortgage Debt	259.59%	267.74%	261.60%	231.85%
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Refi Rate	3.84%	3.74%	3.84%	4.42%
Default Rate	0.95%	0.47%	0.80%	0.12%
Bank Failure Rate	0.33%	0.50%	0.30%	0.94%
Value Function, B	0.379	+0.27%	+0.30%	+1.85%
Value Function, D	0.374	+0.47%	+0.25%	+0.07%
Value Function, I	0.068	-0.21%	-0.61%	-1.91%

## Comparison: Alternative Contracts

- ▶ Eliminates most foreclosures, but does so by shrinking leverage, not improving insurance  $\implies$  banks dislike.

	No Index	Regional	Reg. IO	Reg. Asym.
Deposits	2.454	2.526	2.484	2.196
House Price	8.842	8.784	8.806	8.488
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Value Function, B	0.379	+0.27%	+0.30%	+1.85%
Value Function, D	0.374	+0.47%	+0.25%	+0.07%
Value Function, I	0.068	-0.21%	-0.61%	-1.91%

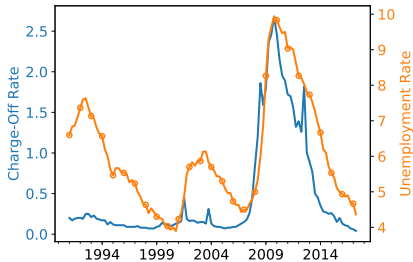
# Conclusion

- ▶ General equilibrium model of intermediated mortgage market allowing for indexed mortgage contracts.
- ▶ Effect depends on type of indexation:
  - Aggregate indexation: **amplifies** intermediary sector instability.
  - Local indexation: **dampens** intermediary sector instability.
- ▶ Costs of indexation partly born by taxpayer
- ▶ Nature of indexation matters for macro implications
  - Indexing principal more effective than interest.
  - Asymmetric indexation has potent effects, but largely through leverage.
  - Misalignment between bank, social incentives may be major obstacle.

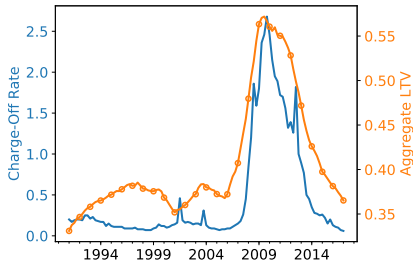


# Strategic vs. Liquidity Defaults

- ▶ Liquidity shocks only turn into defaults when borrower is underwater (double trigger).
- ▶ Reducing principal burden may be most effective way to prevent liquidity defaults.



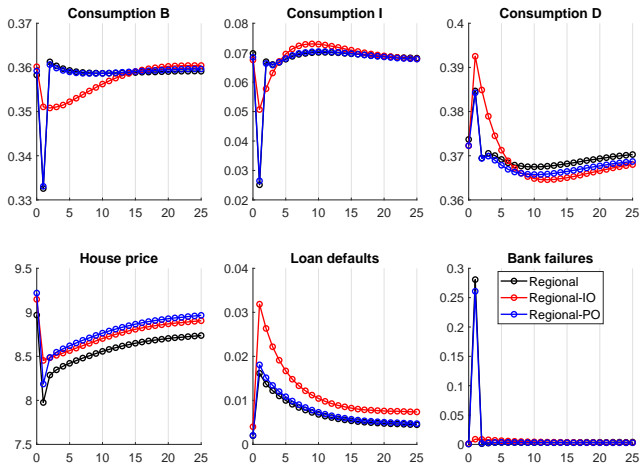
(a) Charge-Offs vs. Unemp.



(b) Charge-Offs vs. LTV

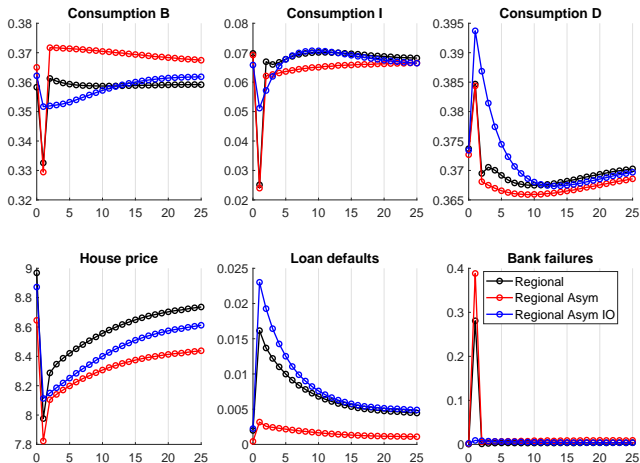
# Interest vs. Principal Indexation

- ▶ Comparison: regional indexation vs. regional interest-only indexation vs. regional principal-only indexation.



# Asymmetric Indexation

- ▶ Asymmetric indexation: cap upward indexation at 20% for each component.



# Transition Comparison: Asymmetric Contracts

► Black: response on impact. Blue: steady state response.

	No Index	Regional	Reg. Asym.	Reg. Asym. IO
Welfare	0.821	+0.61% (+0.32%)	+0.90% (+0.73%)	+0.28% (+0.25%)
$V^B$	0.379	+0.68% (+0.27%)	+1.76% (+1.85%)	+0.36% (+0.53%)
$V^D$	0.374	+0.54% (+0.47%)	+0.11% (+0.07%)	+0.47% (+0.37%)
$V^I$	0.068	+0.53% (-0.21%)	+0.51% (-1.91%)	-1.25% (-2.02%)
$C^B$	0.359	+0.50% (+0.08%)	-1.00% (+1.92%)	-0.18% (+0.51%)
$C^D$	0.372	+0.82% (+0.26%)	+0.47% (+0.05%)	+2.42% (+0.44%)
$C^I$	0.068	+4.63% (-0.40%)	+18.26% (-1.65%)	+0.35% (-2.88%)
Deposits	2.454	+5.98% (+2.90%)	-8.34% (-10.52%)	+3.79% (-3.31%)
$p$	8.842	+2.30% (-0.66%)	-2.11% (-4.01%)	+0.73% (-2.03%)
$M^B$	2.596	+4.76% (+3.14%)	+4.76% (-10.69%)	+4.76% (+0.25%)
$r^*$	1.46%	-0.04pp (-0.11pp)	+0.80pp (+0.91pp)	+0.06pp (+0.09pp)
Refi Rate	3.84%	-0.00pp (-0.09pp)	-0.82pp (+0.59pp)	-0.15pp (-0.27pp)
Loss Rate	0.40%	-0.33pp (-0.20pp)	+0.42pp (+0.51pp)	-0.11pp (-0.05pp)
Failures	0.33%	-0.24pp (+0.16pp)	-0.29pp (+0.60pp)	-0.20pp (+0.01pp)

# Transition Comparison: Interest vs. Principal

► Black: response on impact. Blue: steady state response.

	No Index	Regional	Regional IO	Regional PO
Welfare	0.821	+0.61% (+0.32%)	+0.36% (+0.20%)	+0.51% (+0.18%)
$V^B$	0.379	+0.68% (+0.27%)	+0.61% (+0.30%)	+0.83% (+0.33%)
$V^D$	0.374	+0.54% (+0.47%)	+0.34% (+0.25%)	+0.28% (+0.21%)
$V^I$	0.068	+0.53% (-0.21%)	-0.95% (-0.61%)	-0.03% (-0.75%)
$C^B$	0.359	+0.50% (+0.08%)	+0.78% (+0.11%)	+1.11% (+0.29%)
$C^D$	0.372	+0.82% (+0.26%)	+1.49% (+0.28%)	+0.32% (+0.17%)
$C^I$	0.068	+4.63% (-0.40%)	-1.09% (-1.07%)	+3.00% (-1.65%)
Deposits	2.454	+5.98% (+2.90%)	+5.84% (+1.20%)	+6.52% (+4.02%)
$p$	8.842	+2.30% (-0.66%)	+2.58% (-0.40%)	+3.55% (+0.66%)
$M^B$	2.596	+4.76% (+3.14%)	+4.76% (+0.77%)	+4.76% (+4.32%)
$r^*$	1.46%	-0.04pp (-0.11pp)	-0.05pp (-0.05pp)	-0.07pp (-0.14pp)
Refi Rate	3.84%	-0.00pp (-0.09pp)	+0.07pp (+0.01pp)	+0.10pp (-0.08pp)
Loss Rate	0.40%	-0.33pp (-0.20pp)	-0.24pp (-0.08pp)	-0.33pp (-0.20pp)
Failures	0.33%	-0.24pp (+0.16pp)	-0.19pp (-0.03pp)	-0.21pp (-0.02pp)

# Borrower Complete Problem ▶ Back

$$\max_{C_t^B, H_t^B, M_t^*, K_t^*, Z_{D,t}, Z_{R,t}} V^B(K_t^B, A_t^B, M_t^B)$$

subject to

$$\begin{aligned} C_t^B = & \underbrace{(1 - \tau_t)Y_t^B}_{\text{income}} + \underbrace{Z_{R,t} \left( (1 - Z_{D,t})M_t^* - \delta Z_{M,t}M_t^B \right)}_{\text{net new borrowing}} - \underbrace{(1 - \delta)Z_{M,t}M_t^B}_{\text{principal payment}} \\ & - \underbrace{(1 - \tau)Z_{M,t}A_t^B}_{\text{interest payment}} - \underbrace{p_t \left[ Z_{R,t}(1 - Z_{D,t})K_t^* + (v^K - Z_{R,t})Z_{K,t}K_t^B \right]}_{\text{owned housing}} \\ & - \underbrace{\rho_t (H_t^B - K_t^B)}_{\text{rental housing}} - \underbrace{(\Psi(Z_{R,t}) - \bar{\Psi}_t)(1 - Z_{D,t})M_t^*}_{\text{net transaction costs}} - \underbrace{T_t^B}_{\text{lump-sum taxes}} \end{aligned}$$

and

$$\begin{aligned} M_{t+1}^B &= \bar{\pi}^{-1} \zeta_{p,t+1} \left[ Z_{R,t}(1 - Z_{D,t})M_t^* + \delta(1 - Z_{R,t})Z_{M,t}M_t^B \right] \\ A_{t+1}^B &= \bar{\pi}^{-1} \zeta_{p,t+1} \left[ Z_{R,t}(1 - Z_{D,t})r_t^*M_t^* + \delta(1 - Z_{R,t})Z_{M,t}A_t^B \right] \\ K_{t+1}^B &= Z_{R,t}(1 - Z_{D,t})K_t^* + (1 - Z_{R,t})Z_{K,t}K_t^B \\ M_t^* &\leq \phi^K p_t K_t^* \end{aligned}$$

# Bank Complete Problem ▶ Back

$$V^I(W_t^I, S_t^I) = \max_{L_t^*, \tilde{M}_t^I, \tilde{A}_t^I, B_{t+1}^I} W_t^I - J_t^I \\ + E_t \left[ \Lambda_{t,t+1}^I F_\epsilon^I \left( V^I(W_{t+1}^I, S_{t+1}^I) \right) \left( V^I(W_{t+1}^I, S_{t+1}^I) - \epsilon_{t+1}^{I,-} \right) \right]$$

subject to

$$B_{t+1}^I \leq \phi^I \left( q_t^A \tilde{A}_t^I + q_t^M \tilde{M}_t^I \right)$$

$$J_t^I = \underbrace{(1 - r_t^* q_t^A - q_t^M) L_t^*}_{\text{net new debt}} + \underbrace{q_t^A \tilde{A}_t^I}_{\text{IO strips}} + \underbrace{q_t^M \tilde{M}_t^I}_{\text{PO strips}} - \underbrace{q_t^f B_{t+1}^I}_{\text{new deposits}}$$

$$W_{t+1}^I = \underbrace{\left[ X_{t+1} + Z_{A,t+1} \left( (1 - \delta) + \delta Z_{R,t+1} \right) \right] M_{t+1}^I + Z_{A,t+1} A_{t+1}^I}_{\text{payments on existing debt}} \\ + \underbrace{\delta (1 - Z_{R,t+1}) Z_{A,t+1} \left( q_{t+1}^A A_{t+1}^I + q_{t+1}^M M_{t+1}^I \right)}_{\text{sales of IO and PO strips}} - \underbrace{\pi_{t+1}^{-1} B_{t+1}^I}_{\text{deposit redemptions}}$$

where  $X_t = \frac{(1 - Z_{K,t}) K_t^B (p_t^{REO} - v^{REO} p_t)}{M_t^B}$

# Calibration: All Parameters [▶ Back](#)

Parameter	Name	Value	Target/Source
Agg. income persistence	$\rho_{TFP}$	0.977	Real per capita labor income BEA
Agg. income st. dev.	$\sigma_{TFP}$	0.008	Real per capita labor income BEA
Housing st. dev. (Normal)	$\bar{\sigma}_{\omega,L}$	0.200	Mortg. delinq. rate US banks, no crisis
Housing st. dev. (Crisis)	$\bar{\sigma}_{\omega,H}$	0.250	Mortg. delinq. rate US banks, crisis
Profit shock st. dev.	$\sigma_{\epsilon}$	0.070	FDIC bank failure rate
Fraction of borrowers	$\chi_B$	0.343	SCF 1998 population share LTV > .30
Fraction of intermediaries	$\chi_I$	0.020	Stock market cap. share of finance sector
Borr. inc. and housing share	$s_B$	0.470	SCF 1998 income share LTV > .30
Intermediary inc. and housing share	$s_I$	0.067	Employment share in finance
Tax rate	$\tau$	0.147	Personal tax rate BEA
Housing stock	$\bar{K}$	1	Normalization
Inflation rate	$\pi$	1.006	2.29% CPI inflation
Mortgage duration	$\delta$	0.996	Duration of 30-yr FRM
Prepayment cost mean	$\mu_{\kappa}$	0.370	Greenwald (2018)
Prepayment cost scale	$s_{\kappa}$	0.152	Greenwald (2018)
LTV limit	$\phi^K$	0.850	LTV at origination
Maint. cost (owner)	$v^K$	0.006	BEA Fixed Asset Tables
Bank regulatory capital limit	$\phi^I$	0.940	Financial sector leverage
Deadweight cost of bank failures	$\zeta$	0.085	Bank receivership expense rate
Maint. cost (REO)	$v^{REO}$	0.024	REO discount: $p_{ss}^{REO}/p_{ss} = 0.725$
REO sale rate	$s^{REO}$	0.167	Length of foreclosure crisis
Borr. discount factor	$\beta_B$	0.950	Borrower debt/value, SCF
Intermediary discount factor	$\beta_I$	0.950	Equal to $\beta_B$
Depositor discount factor	$\beta_D$	0.998	2% real rate
Risk aversion	$\gamma$	5.000	Standard value
EIS	$\psi$	1.000	Standard value
Housing preference	$\xi$	0.220	Borrower value/income, SCF