Collateral Constraints and Macroeconomic Asymmetries

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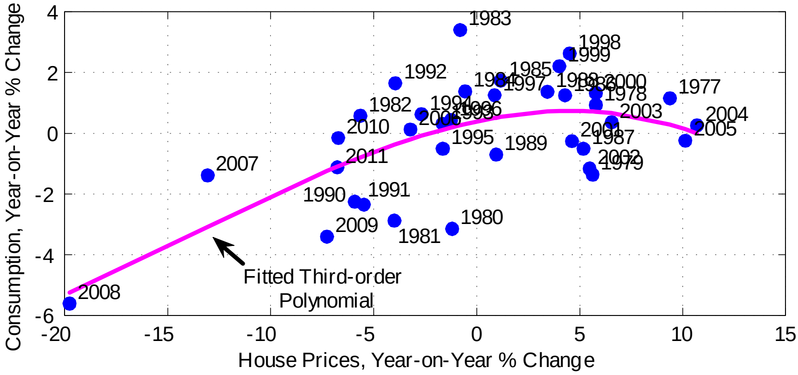

1. House Prices and Consumption are positively correlated in US data
2. Their correlation is larger in periods of low and falling house prices

This Paper

- How much do Housing Boom and Bust contribute to movements in consumption?
  We address this question with a general equilibrium model estimated with Bayesian methods.
  In the model, housing collateral constraints may bind or not, depending on housing wealth, leverage, and the state of the economy.

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  Housing collapse of 2006-2010: Tighter collateral constraints explain three quarters of the fall in consumption.
- Asymmetry is supported by regressions on state- and MSA-level data

Related Papers

DSGE model

- Financial factors and financial shocks and the Great Recession
  Del Negro et al. (2011), Jermann and Quadrini (2012), Christiano, Motto and Rostagno (2013)
  These papers are either calibrated or estimated assuming symmetry/linearity
- Occasionally binding financial constraints and asymmetries in macro models
  Mendoza (2010)
  These papers are not estimated

Regional Analysis

- Housing prices and regional activity
  Case, Quigley and Shiller (2005), Campbell and Cocco (2007), Mian and Sufi (2011), Abdallah and Lastrapes (2012)

The Basic Idea

- Household maximizes $U = E_0 \sum_{t=0}^{\infty} \beta^t \left(\log c_t + j \log h_t\right)$ subject to

$$\begin{aligned} c_t + q_t h_t &= y + b_t - R b_{t-1} + q_t h_{t-1}(1-\delta) \\ b_t &\leq m q_t h_t \\ \log q_t &= \rho \log q_{t-1} + v_t, \; v_t \sim N\left(0, \sigma^2\right) \end{aligned}$$

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- Assume impatience ($\beta R < 1$), fix $y = 1$. The solution of this problem is a consumption function of the form

$$c_t = C\left(q_t, b_{t-1}, h_{t-1}\right)$$

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\end{aligned}
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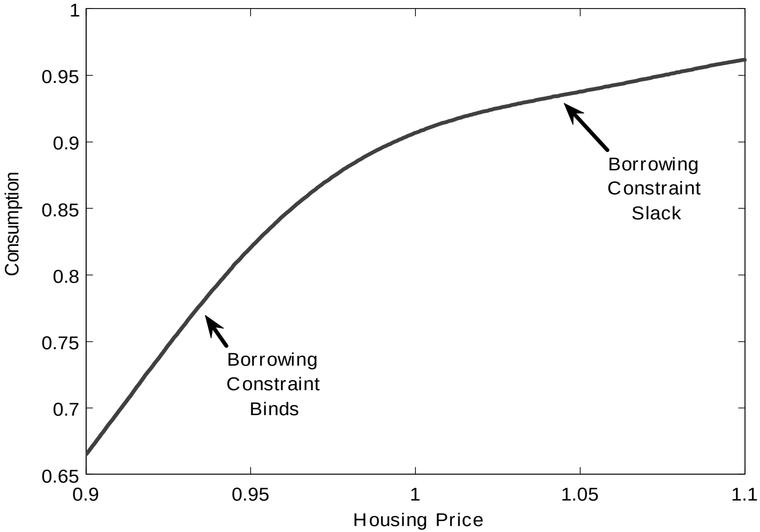
- Consumption function will have the property that consumption increases with house prices, but at a decreasing rate.
  q low –> constraint binds –> consumption moves in lockstep with q
  q high –> constraint is slack –> consumption is less sensitive to q

Model's solution. Consumption function, $c_t = C(q_t, b_{t-1}, h_{t-1})$



In summary:

1. High house prices are associated with slack borrowing constraints, and with a lower sensitivity of consumption to changes in house prices.
2. When household borrowing is constrained – more likely when house prices are low and initial debt is high – sensitivity of consumption to changes in house prices becomes large.

These ideas are developed further both in the full model and in the empirical analysis to follow.

The Full Model: Overview

- Standard monetary DSGE model augmented to include housing collateral constraint along the lines of Kiyotaki and Moore (1997), Iacoviello (2005), and Liu, Wang, and Zha (2013).
  Allow for the dual role of housing as a durable good and as collateral for "impatient" households.
- To this framework, add two elements that generate important nonlinearities.
  1. Housing collateral constraint binds only occasionally.
  2. Monetary policy is constrained by ZLB.
- (Monetary DSGE model: RBC core with price and wage rigidities, habits in consumption, and investment adjustment costs)

Full Model: Households and Preferences

Two household types, each measure 1: patient and impatient.
Within each group, a representative household maximizes:

$$E_0 \sum_{t=0}^{\infty} \beta^t \mathrm{z}_t \left(\Gamma \log \left(c_t - \varepsilon c_{t-1} \right) + \mathrm{j}_t \log h_t - \frac{1}{1+\eta} n_t^{1+\eta} \right),$$

$$E_0 \sum_{t=0}^{\infty} \left(\beta' \right)^t \mathrm{z}_t \left(\Gamma' \log \left(c'_t - \varepsilon c'_{t-1} \right) + \mathrm{j}_t \log h'_t - \frac{1}{1+\eta} n_t'^{1+\eta} \right).$$

z_t : intertemporal preference shock
j_t : housing preference/demand shock

Full Model: Households Constraints

- Patient households maximize their utility subject to:

$$c_t + q_t \Delta h_t + i_t - \frac{R_{t-1} b_{t-1}}{\pi_t} = \frac{w_t n_t}{x_{w,t}} + r_{k,t} k_{t-1} - b_t + div_t,$$

resources are given by wage, capital income, housing wealth, dividends, loan proceeds.

- Impatient households maximize subject to:

$$c'_t + q_t \Delta h'_t + \frac{R_{t-1}}{\pi_t} b_{t-1} = \frac{w'_t}{x'_{w,t}} n'_t + b_t + div'_t,$$

$$b_t \leq \gamma \frac{b_{t-1}}{\pi_t} + (1-\gamma)\, \mathrm{m} q_t h'_t$$

Maximum borrowing b_t = value of house times LTV ratio m
Resources given by wage and housing wealth less loan repayment.
Borrowing constraint allows for inertia, measured by γ

Full Model: Monetary Policy and Supply Side

- Monetary policy follows Taylor rule that responds to annual inflation and GDP in deviation from trend, subject to the zero lower bound (ZLB):

$$R_t = \max\left[1, R_{t-1}^{r_R}\widetilde{\pi}_{a,t}^{(1-r_R)r_\pi}\widetilde{Y}_{t-1}^{(1-r_R)r_Y}\overline{R}^{1-r_R}\mathrm{u}_{r,t}\right].$$

where $\mathrm{u}_{r,t}$ is an iid monetary policy shock.

- The supply side of the model is completed by production function...

$$Y_t = n_t^{(1-\sigma)(1-\alpha)} n_t'^{\sigma(1-\alpha)} k_{t-1}^{\alpha}$$

- ... and price and wage Phillips curves (derived under Calvo wage and price stickiness).

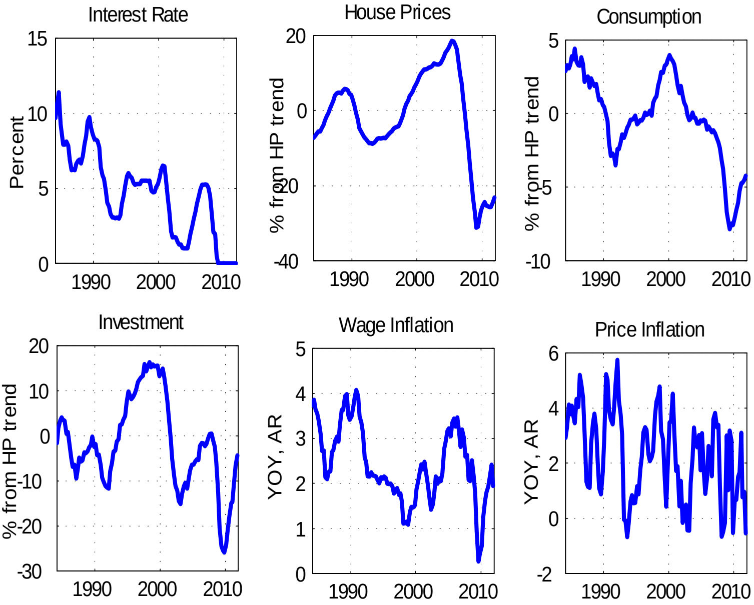
Two Important Parameters

Parameter	Restriction	Measures
σ	b/w 0 and 1	Collateral Constraints
β'	less than β	Asymmetries

- σ measures wage share of impatient households and importance of collateral constraints.
  When $\sigma = 0$, financial frictions disappear, and the model is a standard monetary DSGE model.
- β' measures the importance of asymmetries.
  With β' very low (relative to β), the asymmetries due to financial frictions become small.

Data and Shocks

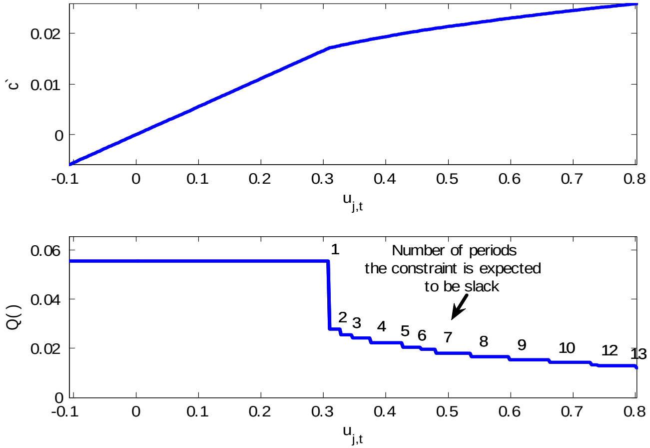
- The estimation is based on observations from 1985Q1 to 2011Q4:
  1. Real Total Household Consumption,
  2. Price (GDP deflator) Inflation,
  3. Wage Inflation (compensation per hour, nonfarm),
  4. Real Business Fixed Investment,
  5. Real Housing Prices (Corelogic),
  6. Federal Funds Rate.
- Six shocks – investment-specific shocks, wage markup, price markup, monetary policy, intertemporal preferences, and preferences for housing.


Interest Rate
Percent
15
10
5
0
1990
2000
2010
House Prices
% from HP trend
20
0
-20
-40
1990
2000
2010
Consumption
% from HP trend
5
0
-5
-10
1990
2000
2010
Investment
% from HP trend
20
10
0
-10
-20
-30
1990
2000
2010
Wage Inflation
YOY, AR
5
4
3
2
1
0
1990
2000
2010
Price Inflation
YOY, AR
6
4
2
0
-2
1990
2000
2010

Solution Method

- We solve the model using the Occbin algorithm (see Guerrieri and Iacoviello, JME): the algorithm extends a first-order perturbation approach and applies it in a piecewise fashion to handle DSGE models with occasionally binding constraints.
- Depending on whether the zero lower bound binds or not, and depending on whether the collateral constraint binds or not, we identify four regimes.
- The solution method links the first-order approximation of the equilibrium conditions describing each regime.
- The dynamics in each regime depend on the expected duration of the regime. In turn, the expected duration depends on the state vector.
- The advantage of the method is its accuracy and speed. Speed is what allows us to compute the model's likelihood in seconds.

The Local Linearity of the Policy Functions



Computing the Likelihood

- Each period, the model solution takes the form:

$$X_t = \mathbf{P}(X_{t-1}, \epsilon_t) X_{t-1} + \mathbf{D}(X_{t-1}, \epsilon_t) + \mathbf{Q}(X_{t-1}, \epsilon_t)\epsilon_t$$

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- In terms of observables, through observation equation $Y_t = \mathbf{H}X_t$,:

$$Y_t = \mathbf{HP}(X_{t-1}, \epsilon_t)X_{t-1} + \mathbf{HD}(X_{t-1}, \epsilon_t) + \mathbf{HQ}(X_{t-1}, \epsilon_t)\epsilon_t$$

We initialize X_0 and recursively solve for ϵ_t, given X_{t-1} and current Y_t.

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- Given that ϵ_t is $NID(0, \mathbf{\Sigma})$, a change in variables argument implies that the log likelihood for $Y^T \equiv \{Y_t\}_{t=1}^T$ given parameters can be derived analytically as:

$$\log f(Y^T) = -\frac{T}{2}\log(\det(\mathbf{\Sigma})) - \frac{1}{2}\sum_{t=1}^{T}\epsilon_t'\left(\mathbf{\Sigma}^{-1}\right)\epsilon_t + \sum_{t=1}^{T}\log(|\det\frac{\partial \epsilon_t}{\partial Y_t}|)$$

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- where $\frac{\partial \epsilon_t}{\partial Y_t}$ is the Jacobian matrix of the transformation from the shocks to the observations

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- We impose standard prior on the parameters and obtain the posterior using random walk Metropolis-Hastings algorithm.

Calibration

m	Maximum LTV	0.9
η	labor disutility	1
β	discount factor, patient agents	0.995
$\overline{\pi}$	steady-state gross inflation rate	1.005
α	capital share in production	0.3
δ	capital depreciation rate	0.025
$\bar{j}$	housing weight in utility	0.04
X_p, X_w	average price and wage markup	1.2

We estimate:

- the parameters governing the shocks processes;
- the parameters governing the nominal and real rigidities;
- the parameters governing the monetary policy rule;
- the wage share of impatient households, and their discount rate.

Model Results: Selected Estimated Parameters

		Prior type [mean, std]	Posterior Mode
β'	discount factor, impatients	normal [0.99, .0015]	**0.9895**
σ	wage share, impatients	beta [0.5, 0.20]	**0.4151**
ε	habit in consumption	beta [0.5, 0.1]	**0.6399**
ϕ	investment adjustment cost	gamma [5, 2]	**5.0307**
r_π	inflation resp. Taylor rule	normal, 1.5, 0.25]	**1.7385**
r_R	inertia Taylor rule	beta [0.75, 0.1]	**0.5200**
r_Y	output response Taylor rule	beta [0.125, 0.025]	**0.0796**
θ_π	Calvo parameter, prices	beta [0.5, 0.075]	**0.9190**
θ_w	Calvo parameter, wages	beta [0.5, 0.075]	**0.9170**
γ	inertia borrowing constraint	beta [0.5, 0.1]	**0.4547**

Specification Checks and Sensitivity Analysis

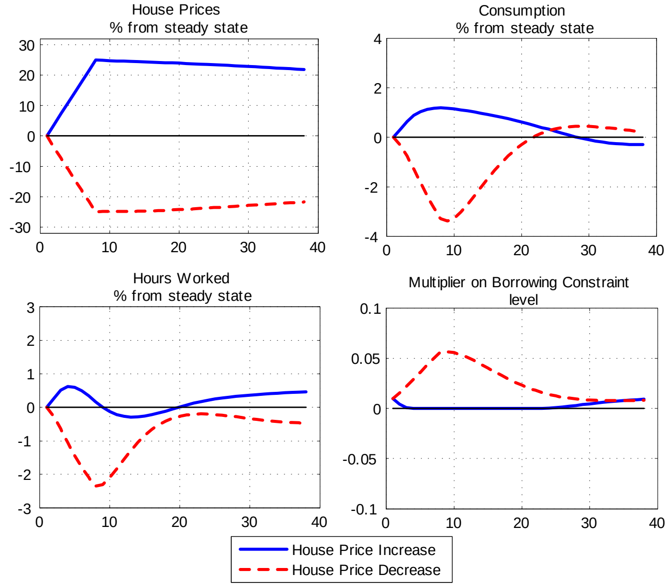
Checks on the Estimation Procedure

1. Re-estimate model assuming different initialization scheme
2. Filter shocks assuming true parameters are known
3. Estimate shocks and parameters from data generated by artificial model

Checks on the Model Specification

1. Use different detrending method
2. Allow for TFP shocks and variable capital utilization

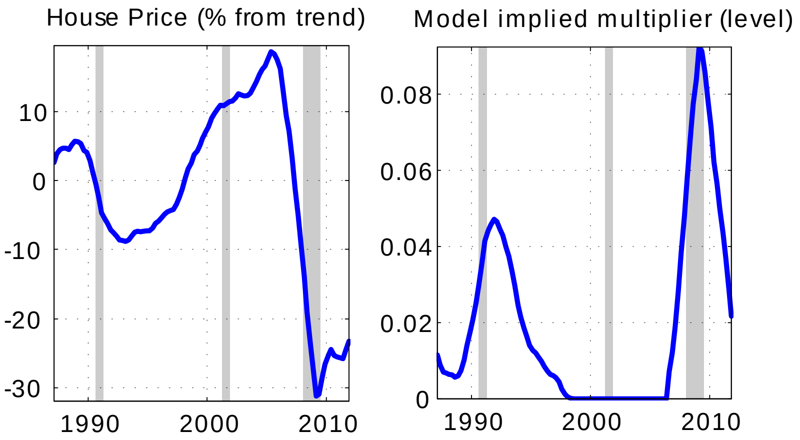
Model Results: Effect of housing demand shocks



Consumption and the Housing Boom and Bust

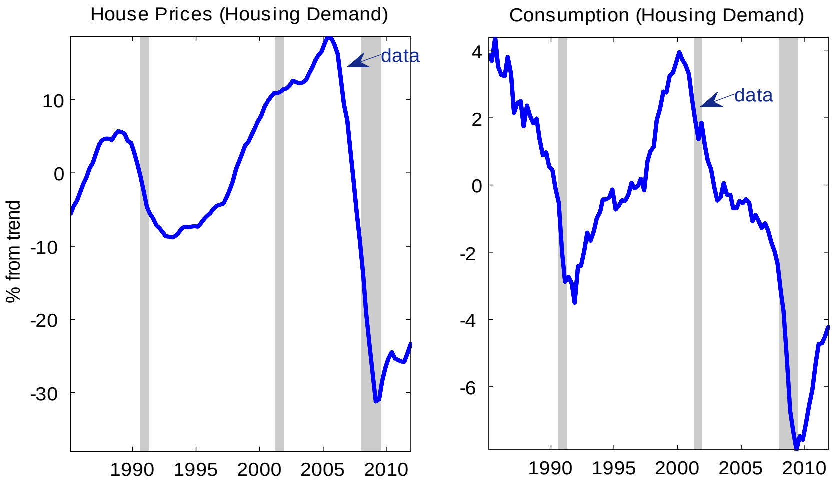
- How much did collateral constraints contribute to the decline in consumption?
- By construction, estimated model explains everything in sample. However, it is important to study which shocks and frictions are important in driving the model's dynamics.
- To understand the importance of collateral constraints, we estimate the restricted model with $\sigma = 0$, and run a horse race between baseline model and model with $\sigma = 0$.

The estimated simulated multiplier



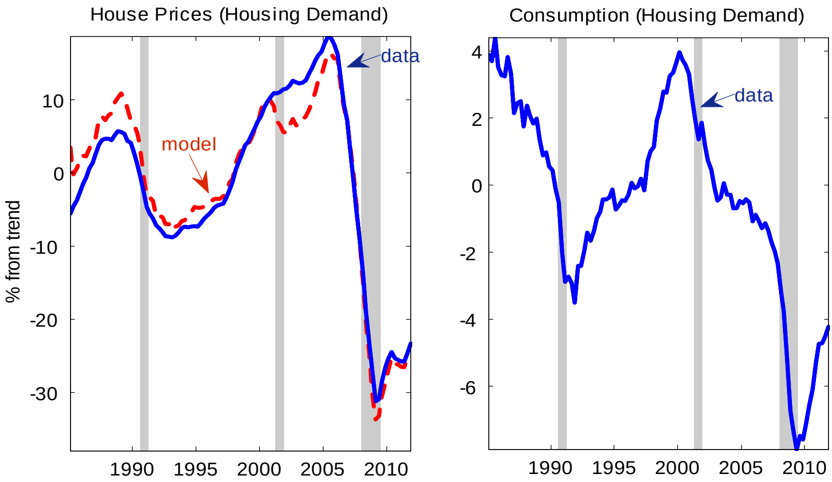
Consumption and House Prices: Data and Model

(Data, and all shocks)



Consumption and House Prices: Data and Model

(Housing Demand Shocks Only)



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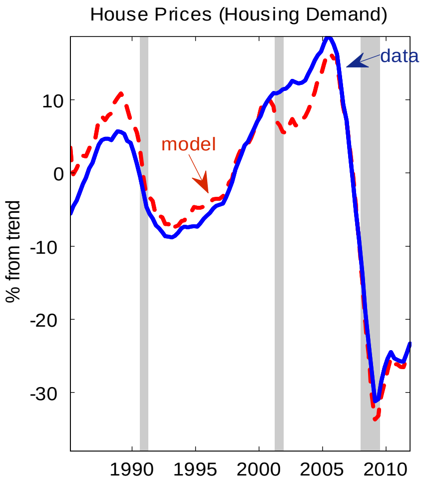
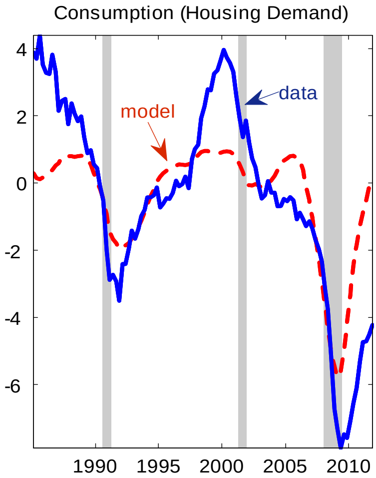
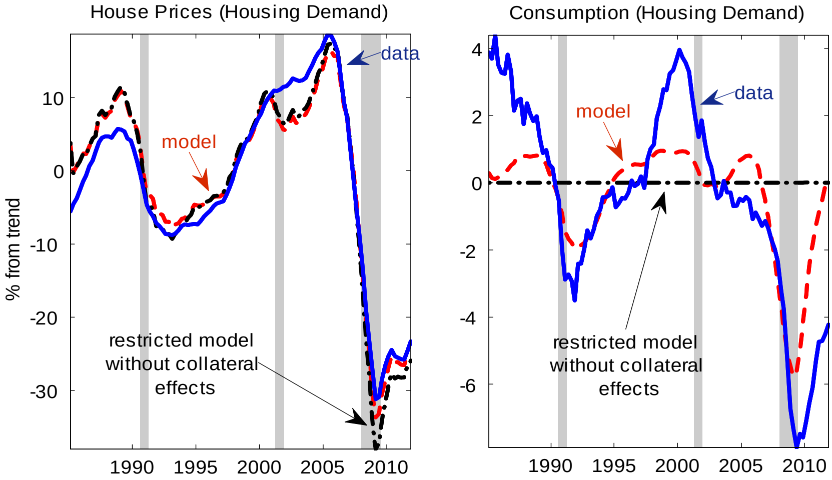




Consumption and House Prices: Data and Model

(Housing Demand Shocks Only - model w/o frictions)



Summary of Comparison

- The baseline model comes close to matching the evolution of both housing and consumption with just the housing shocks,
- By contrast, housing shocks have no bearing on consumption for the model without the collateral constraints.
- Restricted model is completely dependent on a sequence of large consumption shocks to match the consumption data.
- A posterior odds ratio of 90 to 1 favors the baseline model that does not call for the additional sequence of consumption shocks.

Evidence from Regional Data

- We use state-level and MSA-level data from 1990 to 2010

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- Regressions (y is log EMP/CARS/ELE, hp is log house prices) take the form:

$$\begin{aligned} \Delta y_{i,t} &= \alpha_i + \gamma_t + \beta_{HI}\mathcal{I}_{i,t}\Delta hp_{i,t-1} + \beta_{LO}\left(1 - \mathcal{I}_{i,t}\right)\Delta hp_{i,t-1} \\ &\quad + \delta X_{i,t-1} + \varepsilon_{i,t} \end{aligned}$$

$\mathcal{I}_{i,t} = 1$ if house prices are high, 0 if they are low
high: above state-specific trend

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high: above state-specific trend

- **States**: employment in services (EMP), **auto sales (CARS)**, electricity usage (ELE)
- **MSAs**: employment (EMP) and **auto registrations (CARR)**

US States: Auto Sales and House Prices

	% Change in Auto Sales ($\Delta auto_t$)				
Δhp_{t-1}	**0.24*****				
	(0.03)				
Δhp_high_{t-1}		**-0.05**	**0.16*****	**0.11*****	0.07**
		(0.04)	(0.04)	(0.03)	(0.03)
Δhp_low_{t-1}		**0.62*****	**0.33*****	**0.27****	0.20**
		(0.05)	(0.06)	(0.11)	(0.09)
$\Delta auto_{t-1}$				**0.23**	**0.21**
				(0.17)	(0.17)
$\Delta income_{t-1}$					**0.34*****
					(0.11)
Time effects	**no**	**no**	**yes**	**yes**	**yes**
Observations	969	969	969	918	918
R-squared	0.02	0.06	0.86	0.87	0.88

Instrumenting House Prices, MSA

We instrument housing price using housing supply elasticity at the MSA level (data from Albert Saiz), as in Mian and Sufi (2011).

	Cross-sectional Regressions			
	Sample 2002-2006 (Housing Boom)		Sample 2006-2010 (Housing Bust)	
	Δhp	Δcar	Δhp	Δcar
Elasticity	**-7.26***** (0.87)		**4.69***** (0.57)	
Δhp		0.24*** (0.06)		0.49*** (0.08)
Method	OLS	IV	OLS	IV
Observations	254	254	254	254
R-squared	0.22	0.35	0.21	0.48

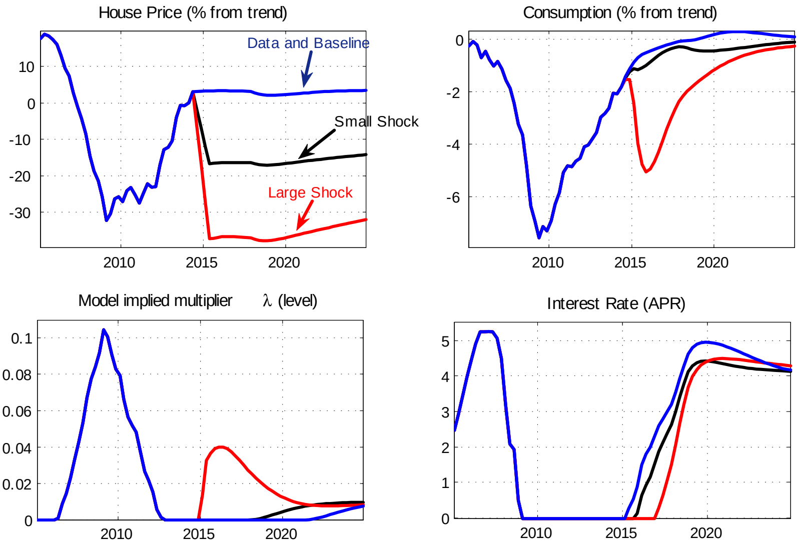
Summary of the Empirical Evidence

Average elasticities measured from the various regressions

	State			MSA
	$\Delta empl$	$\Delta auto$	$\Delta elec$	$\Delta empl$
Δhp_high	0.02	0.07	0.12	0.04
Δhp_low	0.07	0.20	0.19	0.09

1. Average sensitivity of demand to changes in house prices around 0.10
2. Conditioning for low and high prices, sensitivity is around 0.06 when house prices are high, 0.14 for negative changes
3. MSA elasticities after instrumenting house prices and focusing on 2002-2010 period even larger

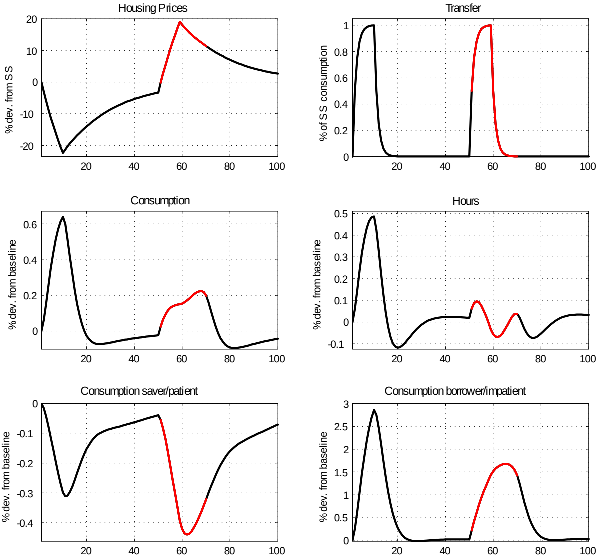
Asymmetry in Motion



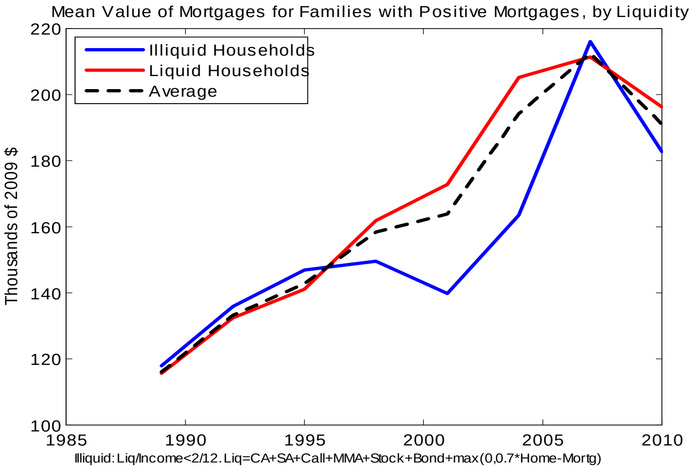
An application to mortgage relief

- Consider a simple proposal such as mortgage relief for debtors
- The marginal effects of mortgage relief depend drastically on whether house prices are high (and few people are constrained) or low (and many people are constrained)
- With low house prices, debt relief can have substantial expansionary effects.

Two transfers from saver to borrower under different house price scenarios

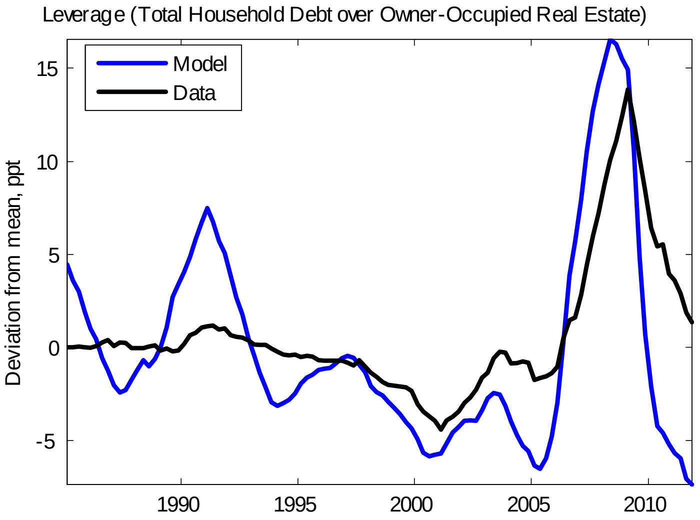


Deleveraging in SCF

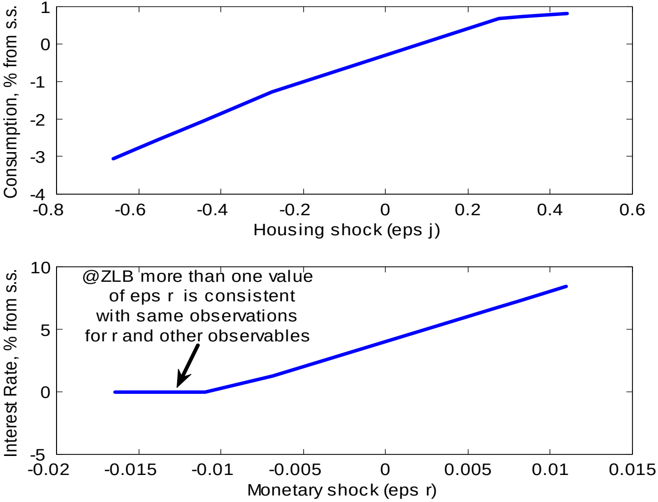


Illiquid households (about 30% of mortgagors) reduced mortgage debt more

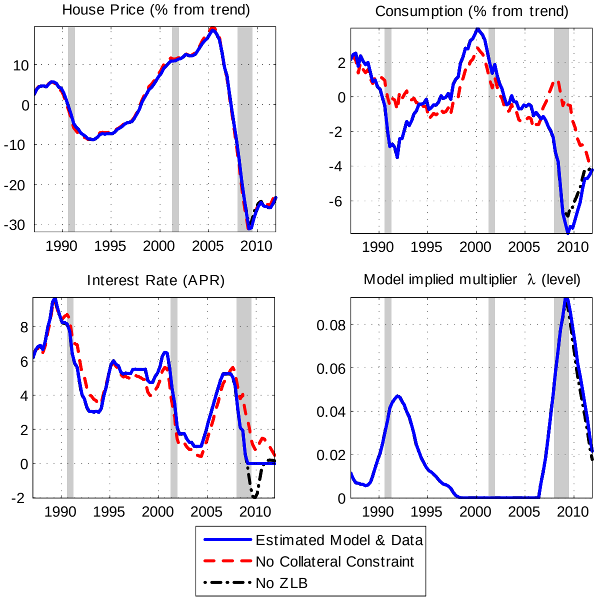
Deleveraging in Aggregate Data and the Model



Does our approach uniquely identify shocks? In practice, yes. Note: exclude interest rate and monetary shocks from observables/shocks when at the ZLB.



The ZLB


House Price (% from trend)
10
0
-10
-20
-30
1990 1995 2000 2005 2010
Consumption (% from trend)
2
0
-2
-4
-6
1990 1995 2000 2005 2010
Interest Rate (APR)
8
6
4
2
0
-2
1990 1995 2000 2005 2010
Model implied multiplier λ (level)
0.08
0.06
0.04
0.02
0
1990 1995 2000 2005 2010
Estimated Model & Data
No Collateral Constraint
No ZLB

Conclusions

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- Ignoring this asymmetry underestimates the effects of shocks to asset prices during recessions.
- The existence of the asymmetry reinforces the findings of many models with collateral constraints that have assumed the asymmetry away.
- Estimated model shows that, as collateral constraints became slack during the housing boom of 2001-2006, expanding housing wealth made little contribution to consumption growth.
  By contrast, the subsequent housing collapse tightened collateral constraints and sharply exacerbated the recession of 2008-2009.