Motivation

- Households' financial position key for propagation of economic shocks and policies (Mian et al., 2013; Schularick and Taylor, 2012).

- Important interplay between borrowing constraints and macro asymmetries in macro models (Eggertsson and Krugman, 2012; Guerrieri and Iacoviello, 2017).

- Policy relevance: large monetary policy interventions and large shifts in household net worth since Great Recession in the US and Europe.
This paper

- Does monetary policy effectiveness depend on the financial position of households in the US economy?

  1. Use a DSGE model to study the interrelation between household balance sheets, borrowing constraints and monetary policy.

  2. Test the model predictions on aggregate US data.

→ Provide guidance on which data to use to measure borrowing constraints.
Preview of results

- Main finding: monetary policy more effective when household net worth is low.
- Amplification effects in the responses of GDP and consumption: up to more than twice as large.

1. DSGE model implies
   - Monetary policy shocks have larger effects when borrowing constraints are binding.
   - Main determinant of binding constraint is the level of net worth.

2. Empirical analysis confirms model predictions
   - Strong and significant effects of monetary policy shocks when net worth is low.
   - Weak and mostly insignificant effects when net worth is high.
Outline

Model

Empirical analysis

Conclusion
Model
Model overview (Guerrieri and Iacoviello, 2017)

- New Keynesian model with occasionally binding housing collateral constraint.

- Dual role of housing: utility & collateral.

- Production: firms and capital stock owned by patient households.

- Wage and price rigidities.

- Monetary policy follows Taylor rule subject to the ZLB.
Households

- Heterogeneous saving preferences generate borrowing and lending.

\[
E_0 \sum_{t=0}^{\infty} z_t (\beta^i)^t \left( \Gamma^i_c \ln(c^i_t - \epsilon_c c^i_{t-1}) + \Gamma^i_h j_t \ln(h^i_t - \epsilon_h h^i_{t-1}) - \frac{1}{1 + \eta} (n^i_t)^1+\eta \right)
\]

for \( i = \{P, I\} \) and \( \beta^I < \beta^P \)

- s.t. budget constraints and the collateral constraint

\[
b_t \leq \gamma \frac{b_{t-1}}{\pi_t} + (1 - \gamma) M q_t h^I_t,
\]

where \( M \) is the maximum borrowing limit (LTV).

- Housing wealth is occasionally crucial for debt dynamics.
Model Estimation

- Data (1960q1-2018q1): consumption, price inflation, wage inflation, investment, house prices, FFR.

- Shocks: housing preference, investment specific, price markup, wage markup, consumption preference, monetary policy.

- Solution: OccBin (Guerrieri and Iacoviello, 2015).
  - model features 4 regimes; approximation around steady state.

- Bayesian estimation: deterministic filter (Guerrieri and Iacoviello, 2017).
A contractionary 100bp monetary policy shock

- Output
- Consumption
- Patient consumption
- Impatient consumption

% Δ from St. St.
0 5 10 15
-1
-0.5
0
% Δ from St. St.
0 5 10 15
-1
-0.5
0
% Δ from St. St.
0 5 10 15
-1
-0.5
0
% Δ from St. St.
0 5 10 15
-1
-0.5
0

-3
-2
-1
0

Quarters
-3
-2
-1
0

\[
\text{no debt-deflation} \quad \text{slack constraint} \quad \text{binding constraint}
\]
Determinants of borrowing constraints

• Question: How to measure borrowing constraints in the data?

• Answer: Estimate determinants of borrowing constraint.

• Approach:
  1. Use estimated DSGE model to simulate artificial time series.
  2. Estimate probit regressions for a slack constraint variable on different measures of “financial excess”.

• Metric: predictive performance for binding/slack constraint.
The level of (impatient) net worth alone is very informative about the state of the borrowing constraint.

Other variables have quantitatively much worse predictive performance.

→ Monetary policy more effective when net worth is low.

Table 1: Prediction of binding collateral constraints

<table>
<thead>
<tr>
<th>predictor candidate $x_k$</th>
<th>levels</th>
<th>growth rates</th>
<th>HP-cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>net worth (impatient)</td>
<td>0.87</td>
<td>0.55</td>
<td>0.69</td>
</tr>
<tr>
<td>net worth (aggregate)</td>
<td>0.59</td>
<td>0.50</td>
<td>0.54</td>
</tr>
<tr>
<td>leverage (impatient)</td>
<td>0.83</td>
<td>0.54</td>
<td>0.65</td>
</tr>
<tr>
<td>leverage (aggregate)</td>
<td>0.56</td>
<td>0.55</td>
<td>0.57</td>
</tr>
<tr>
<td>credit</td>
<td>0.62</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>house prices</td>
<td>0.66</td>
<td>0.54</td>
<td>0.69</td>
</tr>
<tr>
<td>credit gaps</td>
<td>0.57</td>
<td>0.49</td>
<td>0.49</td>
</tr>
</tbody>
</table>
Empirical analysis
Estimation approach

- Local projections as proposed by Jordà (2005)
  \( y_{t+h} = \tau t + I_{t-1} [\alpha_{A,h} + \psi_{A,h}(L)x_t + \beta_{A,h}shock_t] + (1 - I_{t-1}) [\alpha_{B,h} + \psi_{B,h}(L)x_t + \beta_{B,h}shock_t] + \epsilon_{t+h} \)

- Dummy \( I_t \) indicates the state \( \{A, B\} \) of the economy

- \( shock_t \) measures monetary policy shock

- \( \beta_{A,h}, \beta_{B,h} \) provide state-dependent response of \( y_{t+h} \)
• Analysis based on quarterly US data (1960q1 2018q1)

• $l_t$: State of the household net worth cycle (high or low)
  - HP-filter smooth cycle ($\lambda = 100,000$)

• Monetary policy shock
  - State-dependent monetary policy rule, $r = f(l, y, p, n, s)$.
  - recursive identification: $r$ reacts contemporaneously to $y, p, n$.
  - $r$ measured by federal funds rate and shadow rate (Wu-Xia 2016) during the ZLB period.
States of the household net worth cycle
Baseline (cumulative) results: contractionary MP shock

Low net worth

High net worth

GDP

Consumption

Quarters
Robustness

Baseline results robust to:

1. Excluding net worth, ordering of the variables (spread).

2. Alternative definition of state variable.

3. Different identification (Romer/Romer, long-term rate).

4. Sign of the monetary policy shock.

5. Changes in the sample.
Conclusion
• Standard New Keynesian model with financial frictions suggests monetary policy more effective when household net worth is low.

• Model predictions are supported when looking at US macro data.

• Household net worth plays an important role in understanding:
  • Household borrowing constraints.
  • The transmission of monetary policy to the economy.
Additional slides
Budget constraints and capital accumulation

- **Budget constraints**

\[
\begin{align*}
  c_t^P + q_t h_t^P + b_t + i_t &= \frac{w_t^P n_t^P}{x_{w,t}^P} + q_t h_{t-1}^P + \frac{R_{t-1} b_{t-1}}{\pi_t} + r_k k_{t-1} + \text{div}_t^P \\
  c_t' + q_t h_t' + \frac{R_{t-1} b_{t-1}}{\pi_t} &= \frac{w_t' n_t'}{x_{w,t}'} + q_t h_{t-1}' + b_t
\end{align*}
\]

- **Capital accumulation**

\[
k_t = a_t \left( i_t - \phi \left( \frac{i_t - i_{t-1}}{\bar{i}_t} \right)^2 \right) + (1 - \delta) k_{t-1},
\]
Wholesale firms produce intermediate goods $y_t$

$$\max_{x_{p,t}} \frac{y_t}{x_{p,t}} - w_t n_t - w'_t n'_t - r k_t k_{t-1}$$

subject to the production technology

$$y_t = n_t^{(1-\sigma)(1-\alpha)} n_t^{\sigma(1-\alpha)} k_{t-1}^\alpha,$$

where $\sigma$ measures the labor income share of impatient households.
Wholesale firms

Calvo-style wage rigidities imply the following linearized wage Phillips curves:

\[
\ln(\omega_t/\bar{\pi}) = \beta E_t \ln(\omega_{t+1}/\bar{\pi}) - \varepsilon_w \ln(x_{w,t}/\bar{x}_w) + u_{w,t},
\]

\[
\ln(\omega^I_t/\bar{\pi}) = \beta^I E_t \ln(\omega^I_{t+1}/\bar{\pi}) - \varepsilon^I_w \ln(x^I_{w,t}/\bar{x}_w^I) + u_{w,t},
\]

where \(\varepsilon_w = (1 - \theta_w)(1 - \beta\theta_w)/\theta_w\), \(\varepsilon^I_w = (1 - \theta_w)(1 - \beta^I\theta_w)/\theta_w\), \(\omega_t = \frac{w_t \pi_t}{w_{t-1}}\), \(\omega^I_t = \frac{w^I_t \pi_t}{w^I_{t-1}}\), and \(u_{w,t}\) is a normally distributed i.i.d. wage markup shock.
The solution has the form

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

(1)

where $X_t$ contains all the variables of the model and $\epsilon_t$ is the vector of innovations to the shock processes.

The model can be taken to the data with the following observation equation

$$Y_t = H_tP(X_{t-1}, \epsilon_t)X_{t-1} + H_tD(X_{t-1}, \epsilon_t) + H_t Q(X_{t-1}, \epsilon_t)\epsilon_t.$$

(2)
## Calibrated parameters

<table>
<thead>
<tr>
<th>parameter</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>patient discount factor 0.995</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>capital share in production 0.3</td>
</tr>
<tr>
<td>$\delta$</td>
<td>capital depreciation rate 0.025</td>
</tr>
<tr>
<td>$\bar{\bar{j}}$</td>
<td>housing weight in utility 0.04</td>
</tr>
<tr>
<td>$\eta$</td>
<td>labor disutility 1</td>
</tr>
<tr>
<td>$\bar{x}_p$</td>
<td>price markup 1.2</td>
</tr>
<tr>
<td>$\bar{x}_w$</td>
<td>wage markup 1.2</td>
</tr>
<tr>
<td>$\bar{\pi}$</td>
<td>steady state inflation 1.0075</td>
</tr>
<tr>
<td>$r_Y$</td>
<td>weight of GDP in Taylor rule 0.1</td>
</tr>
<tr>
<td>$M$</td>
<td>steady state LTV limit 0.9</td>
</tr>
<tr>
<td>$\beta^I$</td>
<td>impatient discount factor 0.9922</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>inertia, borrowing const. 0.6945</td>
</tr>
</tbody>
</table>
### Table 2: Estimated Parameters

<table>
<thead>
<tr>
<th>parameter</th>
<th>prior</th>
<th>posterior mode</th>
<th>5%</th>
<th>median</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon_c$</td>
<td>habit in consumption</td>
<td>BETA 0.70(0.10)</td>
<td>0.4295</td>
<td>0.3804</td>
<td>0.4559</td>
</tr>
<tr>
<td>$\varepsilon_h$</td>
<td>habit in housing</td>
<td>BETA 0.70(0.10)</td>
<td>0.9208</td>
<td>0.8888</td>
<td>0.9223</td>
</tr>
<tr>
<td>$\phi$</td>
<td>invest. adjustment cost</td>
<td>GAMMA 5.00(2.00)</td>
<td>11.0144</td>
<td>8.5145</td>
<td>11.2128</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>wage share impatient HH.</td>
<td>BETA 0.50(0.05)</td>
<td>0.4324</td>
<td>0.4046</td>
<td>0.4320</td>
</tr>
<tr>
<td>$r_\pi$</td>
<td>Taylor Rule, inflation</td>
<td>NORMAL 1.50(0.10)</td>
<td>1.4427</td>
<td>1.3901</td>
<td>1.6175</td>
</tr>
<tr>
<td>$r_R$</td>
<td>Taylor Rule, inertia</td>
<td>BETA 0.75(0.10)</td>
<td>0.2506</td>
<td>0.1419</td>
<td>0.2248</td>
</tr>
<tr>
<td>$\theta_p$</td>
<td>Calvo, prices</td>
<td>BETA 0.50(0.07)</td>
<td>0.9294</td>
<td>0.7960</td>
<td>0.8655</td>
</tr>
<tr>
<td>$\theta_w$</td>
<td>Calvo, wages</td>
<td>BETA 0.50(0.07)</td>
<td>0.9011</td>
<td>0.8764</td>
<td>0.8975</td>
</tr>
<tr>
<td>$\rho_J$</td>
<td>AR(1) housing shock</td>
<td>BETA 0.75(0.10)</td>
<td>0.9876</td>
<td>0.9553</td>
<td>0.9763</td>
</tr>
<tr>
<td>$\rho_K$</td>
<td>AR(1) investment shock</td>
<td>BETA 0.75(0.10)</td>
<td>0.5804</td>
<td>0.5289</td>
<td>0.5839</td>
</tr>
<tr>
<td>$\rho_R$</td>
<td>AR(1) monetary shock</td>
<td>BETA 0.25(0.10)</td>
<td>0.4223</td>
<td>0.3371</td>
<td>0.4864</td>
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<tr>
<td>$\rho_Z$</td>
<td>AR(1) preference shock</td>
<td>BETA 0.75(0.10)</td>
<td>0.8573</td>
<td>0.7559</td>
<td>0.8035</td>
</tr>
<tr>
<td>$\sigma_J$</td>
<td>stdv. housing shock</td>
<td>INVGAMMA 0.01(1.00)</td>
<td>0.0470</td>
<td>0.0394</td>
<td>0.0686</td>
</tr>
<tr>
<td>$\sigma_K$</td>
<td>stdv. investment shock</td>
<td>INVGAMMA 0.01(1.00)</td>
<td>0.0944</td>
<td>0.0702</td>
<td>0.0955</td>
</tr>
<tr>
<td>$\sigma_P$</td>
<td>stdv. price markup shock</td>
<td>INVGAMMA 0.01(1.00)</td>
<td>0.0061</td>
<td>0.0059</td>
<td>0.0068</td>
</tr>
<tr>
<td>$\sigma_R$</td>
<td>stdv. monetary shock</td>
<td>INVGAMMA 0.01(1.00)</td>
<td>0.0051</td>
<td>0.0048</td>
<td>0.0053</td>
</tr>
<tr>
<td>$\sigma_W$</td>
<td>stdv. wage markup shock</td>
<td>INVGAMMA 0.01(1.00)</td>
<td>0.0084</td>
<td>0.0077</td>
<td>0.0084</td>
</tr>
<tr>
<td>$\sigma_Z$</td>
<td>stdv. preference shock</td>
<td>INVGAMMA 0.01(1.00)</td>
<td>0.0154</td>
<td>0.0138</td>
<td>0.0155</td>
</tr>
</tbody>
</table>
Filtered variables and data

- Consumption
- Price inflation
- Wage inflation
- Investment
- House prices
- FFR

**t+1 forecast**
**data**
Amplification of max. response and expected slack duration

![Graph showing amplification factor vs. minimum expected slack quarters]

- Amplification factor
  - GDP
  - Total consumption
  - Impatient consumption

Graph axis:
- Y-axis: Amplification factor
- X-axis: Minimum expected slack quarters

Legend:
- Blue line: GDP
- Red dashed line: Total consumption
- Yellow line: Impatient consumption
A contractionary 100bp monetary policy shock
Determinants of borrowing constraints

Formally, we run regressions

$$\Pr(Y_t = 1 \mid X_{k,t}) = \Phi(X_{k,t}^T \beta_k), \quad k = 1 \ldots K$$ \hfill (3)

where

$$Y_t = \begin{cases} 1 & \text{if } LM > 0 \\ 0 & \text{otherwise} \end{cases} \hfill (4)$$

- $\Phi$ is the CDF of a standard normal distribution.
- $X_{k,t}$ includes a constant and one of the predictor candidates $x_{k,t}$.
- $x_{k,t}$: net worth (aggregate and impatient), leverage (aggregate and impatient), credit, house prices, credit-to-gdp gaps (BIS).
- $LM$ is the Lagrange multiplier on the borrowing constraint.
Net worth and borrowing constraints
Net worth and monetary policy

![Graphs showing output, consumption, patient consumption, and impatient consumption with different net worth scenarios.](image)

- **Output**
- **Consumption**
- **Patient consumption**
- **Impatient consumption**

Legend:
- **no debt-deflation**
- **high net worth**
- **low net worth**

---

[back]
Estimation approach

Define the structural IRF of \( y_t \) to \( shock_t \) at horizon \( h \) as

\[
IRF(h, shock_t) = E(y_{t+h}|shock_t = \delta) - E(y_{t+h}|shock_t = 0)
\]

This can be computed with regressions

\[
y_{t+h} = \tau t + I_{t-1} [\alpha_{A,h} + \psi_{A,h}(L)x_t + \beta_{A,h}shock_t] + (1 - I_{t-1}) [\alpha_{B,h} + \psi_{B,h}(L)x_t + \beta_{B,h}shock_t] + \epsilon_{t+h}
\]

where \( h = 1, \ldots, H \) and

\[
shock_t = r_t - E(r_t|\omega_{kt})
\]

\[
\omega_{kt} = (r_{t-1}, r_{t-2}, y_t, y_{t-1}, y_{t-2}, p_t, p_{t-1}, p_{t-2},
\]

\[
n_t, n_{t-1}, n_{t-2}, s_{t-1}, s_{t-2})
\]

\( x_t \) additionally includes 2 lags of \( y_t \).
Baseline results: contractionary MP shock

![Graphs showing GDP and Consumption for Low and High net worth categories over quarters.](image)
Baseline results: contractionary MP shock

![Graphs showing FFR, Investment, and Inflation over Quarters for Low and High net worth scenarios.](image-url)
Linear model: contractionary MP shock

- **GDP**: Shows a slight decrease over time, indicating a contractionary effect.
- **Consumption**: Consists mostly of a horizontal line, suggesting little to no change over time.
- **Investment**: Demonstrates a decrease, aligning with the contractionary shocks.
- **Inflation**: Comments on a slight inflationary effect over the quarters.
Alternative identification and state definition: GDP
Alternative samples: GDP
Sign of monetary policy shocks

Notes: Monetary policy shocks during a high household net worth state: 50% positive and 50% negative. Monetary policy shocks during a low household net worth: 46% positive and 54% negative. 52% of the positive shocks happened during a low household net worth state, while 55% of the negative shocks occurred during a low net worth state.