Financial Frictions, Asset Prices, and the Great Recession

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We have had a Great Recession

- Both in the U.S. and in (mostly Southern) Europe
- Large decline in output, employment, consumption, and investment.
- Households deleveraging process: private debt and housing prices plunged.
- Total factor productivity (TFP) dropped.
Facts on the last recession: I

Note: Except for unemployment, figures show percentage deviation from a linear trend.
Facts on the last recession: II

Wealth to output

Debt to output

Housing value to output

Labor Quality adjusted Productivity
Summary of the facts

- Large decline in output, employment, consumption, and investment.

- Households deleveraging process: private debt and housing price plunged.

- Total factor productivity dropped.
Objective: Ask whether large recessions can be triggered by worse financial conditions faced by households?

- We need a macro growth model with certain properties to be able to even ask this question.

1. Households differing in wealth and job market prospects.
2. A financial system used widely by not-too-rich households to buy houses (loans have to be collateralized).
3. Asset prices that respond to market conditions: endogenous housing and stock market prices.
4. Some endogenous mechanism that moves measured TFP.

- We extend [?] and [?] [?] [?] in various ways to include a production sector and housing and asset prices that allows us to talk about the U.S. recession.
Findings: The answer is yes, provided there are (from + to -)

1. Real frictions that difficult the switch from production of consumption goods to exports or investment.

2. Houses which are inferior goods and not wanted by the super-rich.

3. Frictions in the goods markets that generate movements in measured GDP.

4. Households that differ in job prospects.

5. Some labor market frictions that limit wage adjustments.
Findings: The Recession that we generate

- Shares most of the features of the Great Recession:

1. A large decline in output, employment, consumption and investment.

2. Large reductions in assets (housing and stocks) prices.

3. Lower than the data due to inexistence of default, foreclosures, and adjustment costs in house purchases.
Model
The Model Characteristics

- Enhanced Aiyagari Economy:
  1. Multisector: Tradables and nontradables.
  2. Houses (land) that need to be purchased to be enjoyed.
  3. Endogenous productivity movements (frictions in goods markets).
  4. Various job market frictions.
Households: Preferences

- Continuum of households that live forever ($\beta$), are subject to uninsurable idiosyncratic and aggregate shocks.

- H'holds care about quantities and number of varieties of nontradables.

$$c_N = \left( \int_0^{I_N} c_N^\rho \, di \right)^\rho = c_N^\rho I_N$$

- Households have to search for varieties, its number is a choice.

$$I_N = d \, \Psi^d(Q^g)$$

- $\Psi^d(Q^g)$: Probability (per search unit) of finding a variety (goods market frictions).

- Households also like tradables and housing and dislike goods searching

$$u \left[ c_A(c_N, I_N^\rho, c_T), h, d \right]$$
Households: Endowments and Wealth

- Household skill type is $\epsilon$, follows a Markov chain $\Gamma_{\epsilon,\epsilon'}$. Moves slowly and accommodates opportunities to get rich.

- Households either have a job $e = 1$ or not $e = 0$.
  - Type-dependent exogenous job destruction rate $\delta_{\epsilon}$.
  - Job finding rate is type independent and depends on job creation by firms (workers are rationed, it is like no matching function in labor market but hiring costs) ([?]).

- Households have assets $a$. These assets can be allocated to (frictionless) houses and/or to financial assets with a collateral constraint. The poor will have some housing wealth and a mortgage, the rich houses and shares of the economy’s mutual fund.
Goods markets

- Search frictions in the markets for nontradables:
  - Households look for varieties.
  - Random search.
  - Richer people consume and search more.
  - Cuts in consumption cut search which cuts productivity.
  - Perfect competition and frictionless markets for tradables.
Labor market

- Workers are rationed.

- Firms hire as many workers as they wish paying hiring costs. (like a vacancy filling probability of 1, with hiring costs).

- Employment: \( N = N_N + N_T \).

- Same job finding probability across types: \( \Phi^e = \frac{V}{1 - N} \).

- Wages are determined via the following formula

\[
\log w - \log \bar{w} = \varepsilon_w \left( \log \bar{Y} - \log \bar{\bar{Y}} \right)
\]

It simplifies things.
Assets markets: Financial assets and houses

- Total housing \( \bar{H} \) is in fixed supply.

- Negative financial assets \((b' < 0)\) are (undefaultable) mortgages.
  - Its interest rate is predetermined: \( \frac{1}{1 + r^*} - \varsigma(\theta) \), if \( b < 0 \).
  - Mortgages have to be collateralized by housing: if \( b < 0 \) then
    \[
    |b| \leq [1 - \lambda(\theta)] \ p_n(S') \ h \left[ \frac{1}{1 + r^*} - \varsigma(\theta) \right]
    \]

- Positive financial assets \((b > 0)\) are shares of a mutual fund.
  - Its return, \( r(S, S') \), is stochastic. Possible capital gains and loses.
    \[
    R(S, S', b) = \begin{cases} 
    1 + r(S, S'), & \text{if } b \geq 0 \\
    1, & \text{if } b < 0. 
    \end{cases}
    \]
State variables

- A household is characterized by \( \{\epsilon, e, a\} \).

- Let \( X \) denote the measure over types \( x = \{\epsilon, e, a\} \).

- The vector of aggregate state variables is
  \[
  S = \{\theta, B, K_N, K_T, N_N, N_T, X\}
  \]
  Here \( B \) is the net foreign asset position. \( K \) and \( N \) are predetermined factor inputs.

- Hence either we do Krusell-Smith or the transition after an unforeseen shock. Today, we do the latter.
Households’ problem

\[
V(S, \epsilon, e, a) = \max_{c_{N,i}, c_T, I_N, h, d} u(c_A, h, d) +
\]

\[
\beta \sum_{\epsilon', e', \theta'} \Pi^\theta_{\theta', \theta'} \Pi^{w}_{\epsilon', \epsilon} V[S', \epsilon', e', a'(S', b, h)]
\]

s.t.

\[
\int_0^{I_N} p_i(S) c_{N,i} + c_T + p_h(S) h + b = a + 1_{e=1} w(S) \epsilon + 1_{e=0} w
\]

BC

\[
a'(S', b, h) = p_h(S') h + R(S, S', b) b
\]

AA

\[
b \geq -\lambda(\theta) p_h(S) h \left[ \frac{1}{1 + r^*} - \varsigma(\theta) \right]
\]

FC

\[
I_N = d \Psi^d [Q^g(S)]
\]

SC

\[
S' = G(S, \theta')
\]

RE
Nontradables: Monopolistic Competition by Varieties

- Each firm/variety has any locations each.

- Some inputs are location specific. Others (type 2 labor) are not.

- Prices are posted before location is filled

- The demand function is given by

  \[ \Psi^f [Q^g(S)] \int c[p_i(\epsilon, e, a), S, x] \, d(x, S) \]

- The firm has to make sure that it can satisfy the demand at all locations.
Nontradable firms’ problem

\[ \Omega^N(S, k, n) = \max_{i, v, p_i} \Psi^f[Q^g(S)] p_i \int c(p_i, S, \epsilon, e, a) \, dx - w(S) \ell - i - \kappa v \]

subject to

\[ \ell_2 \geq \Psi^f[Q^g(S)] \int f^{\ell}[c(p_i, S, x), k, \ell_1] \frac{d(x, S)}{D(S)} \]

DC

\[ \ell_1 + \ell_2 = n \bar{\epsilon}(S) \]

SL

\[ k' = (1 - \delta_k)k + i - \phi^N(k, i) \]

LMK

\[ n' = [1 - \delta_n(S)]n + v \]

LML

\[ S' = G(S, \theta') \]

RE
Tradable firms’ are competitive and have adjustment costs

- Its output is used for exports, investment, and (part of) consumption.
- Decreasing returns.

\[
\Omega^T(S, k, n) = \max_{i, v} F^T(k, \ell) - w(S)\ell - i - \kappa v - \phi^{T, n}(n', n)
\]

\[
+ \sum_{\theta'} \Pi_{\theta, \theta'} \frac{\Omega^T(S', k', n')}{1 + r^*}
\]

subject to

\[
k' = (1 - \delta_k)k + i - \phi^{T, k}(k, i)
\]

\[
\ell = n \bar{\epsilon}(S)
\]

\[
n' = [1 - \bar{\delta}_n(S')]n + v
\]

\[
S' = G(S).
\]
Mutual fund

- Financial wealth in the economy is
  \[ L_+ = \int_{b>0} b(S, \epsilon, e, a) \, dx \]

- Mortgages in the economy are
  \[ L_- = \int_{b<0} -b(S, \epsilon, e, a) \, dx \]

- Net foreign asset position of the country (the mutual fund owns all firms)
  \[ B = L_+ - \left( \Omega^N(S) - \pi^N(S) + \Omega^T(S) - \pi^T(S) + \frac{1}{1 + r^*} L_- \right) \]

- The realized rate of return is
  \[ 1 + r(S, S') = \frac{\Omega^N(S') + \Omega^T(S') + (1 + r^*)B + L_-}{L_+} \]
Equilibrium

An equilibrium is a set of decision rules and values for households, firms’ values and decision rules, and a set aggregate variables of aggregate states, such that:

- Households’ and firms’ policy functions and value functions solve the corresponding program problems.

- Aggregate searching consistence
  \[
  D(S) = \int d(S, \epsilon, e, a) \, dx,
  \]

- Nontradable prices satisfies
  \[
  p(S) = p_i(S, K_N, N_N) \, dx,
  \]

- Housing market clears
  \[
  \int h(S, \epsilon, e, a) \, dx = H.
  \]
Equilibrium

- Average separation probability and labor force quality

\[ \bar{\delta}_n(S') = \sum_{\epsilon} \frac{\delta_n(\epsilon)n(\epsilon)}{N}, \quad \bar{\epsilon}(S') = \sum_{\epsilon} \frac{\epsilon n(\epsilon)}{N} \]

- Rate of return to the mutual fund satisfies

\[ 1 + r(S, S') = \frac{\Omega^N(S') + \Omega^T(S') + (1 + r^*)B + \int_{b<0} b(S, x)}{\int_{b>0} b(S, x)} \]

- Wage satisfies

\[ \log w(S) - \log w = \varepsilon_w \left( \log Y(S) - \log \bar{Y} \right) \]

- The law of motion \( G(S) \) is consistent with households’ decisions and employment dynamics.
Mapping the Model to Data
Functional forms

- Preferences

\[ u(c_A, h, d) = \frac{1}{1 - \sigma_c} \left( c_A - \xi_d \frac{d^{1+\gamma}}{1 + \gamma} \right)^{1-\sigma_c} + v(h) \]

- where there is an Armington aggregator for consumption

\[ c_A = \left[ \omega (c_N I_N^p) \frac{n-1}{n} + (1 - \omega) c_T^{\eta} \right]^{\frac{n}{\eta-1}} \]

- and houses are inferior goods as a proxy for segmentation of housing markets

\[ v(h) = \begin{cases} \frac{\xi_h}{1 - \sigma_h} (h + h_1)^{1 - \sigma_h^1}, & \text{if } h < \hat{h} \\ \frac{\xi_h}{1 - \sigma_h} (h + h_2)^{1 - \sigma_h^2}, & \text{if } h \geq \hat{h} \end{cases} \]
Housing utility function

Engel Curve: consumption vs housing

Housing
Consumption

Housing function with less curvature
Housing function with more curvature
Functional forms

- Production function

$$F^N(k, \ell_1, \ell_2) = z_N k^{\alpha_0} \ell_1^{\alpha_1} \ell_2^{\alpha_2}, \quad F^T(k, \ell) = z_T k^{\theta_0} \ell^{\theta_1}$$

- Capital adjustment cost in the nontradable goods sector

$$\phi^N(i, k) = \frac{\varepsilon^N}{2} \left( \frac{i}{k} - \delta_k \right)^2 k$$

- Capital and employment adjustment cost in the tradable goods sector

$$\phi^{T,k}(i, k) = \frac{\varepsilon^{T,k}}{2} \left( \frac{i}{k} - \delta_k \right)^2 k, \quad \phi^{T,n}(n', n) = \frac{\varepsilon^{T,n}}{2} \left( \frac{n'}{n} - 1 \right)^2 n$$

- Matching technology

$$M(D, T) = \nu D^\mu T^{1-\mu}$$
Exogenously determined parameters

- A period is half a quarter.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk aversion for consumption, $\sigma_c$</td>
<td>2.0</td>
</tr>
<tr>
<td>Risk aversion for housing, $\sigma_{h}^1$</td>
<td>2.0</td>
</tr>
<tr>
<td>Risk aversion for housing, $\sigma_{h}^2$</td>
<td>10.0</td>
</tr>
<tr>
<td>Curvature of shopping, $\gamma$</td>
<td>1.5</td>
</tr>
<tr>
<td>Elasticity of substitution bw tradables and nontradables, $\eta$</td>
<td>0.80</td>
</tr>
<tr>
<td>Cutoff value for housing utility, $\tilde{h}$</td>
<td>1.4</td>
</tr>
<tr>
<td>Price markup, $\rho$</td>
<td>1.1</td>
</tr>
<tr>
<td>Loan to value ratio, $\lambda$</td>
<td>0.75</td>
</tr>
<tr>
<td>Interest rate for international bonds, $r^*$</td>
<td>4%</td>
</tr>
</tbody>
</table>
## Endogenously determined parameters: aggregate

<table>
<thead>
<tr>
<th>Target</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wealth to output ratio</td>
<td>4.70</td>
<td>$\beta$</td>
<td>0.98</td>
</tr>
<tr>
<td>Housing value to output ratio</td>
<td>1.67</td>
<td>$\xi_h$</td>
<td>0.95</td>
</tr>
<tr>
<td>Debt to output ratio</td>
<td>0.75</td>
<td>$\epsilon_4$</td>
<td>30.77</td>
</tr>
<tr>
<td>Share of tradables</td>
<td>0.30</td>
<td>$\omega$</td>
<td>0.95</td>
</tr>
<tr>
<td>Occupancy Rate</td>
<td>0.81</td>
<td>$\nu$</td>
<td>0.81</td>
</tr>
<tr>
<td>Capital to output ratio</td>
<td>2.00</td>
<td>$\delta_k$</td>
<td>0.01</td>
</tr>
<tr>
<td>Labor Share in nontradables</td>
<td>0.64</td>
<td>$\alpha_0$</td>
<td>0.27</td>
</tr>
<tr>
<td>$\alpha_1 = \alpha_2$</td>
<td></td>
<td>$\alpha_1$</td>
<td>0.36</td>
</tr>
<tr>
<td>Labor Share in tradables</td>
<td>0.66</td>
<td>$\theta_1$</td>
<td>0.66</td>
</tr>
<tr>
<td>$1.4\theta_0 + \theta_1 = 1$</td>
<td></td>
<td>$\theta_0$</td>
<td>0.23</td>
</tr>
<tr>
<td>Vacancy cost to output ratio</td>
<td>0.02</td>
<td>$\kappa$</td>
<td>0.42</td>
</tr>
<tr>
<td>Home production to lowest earning ratio</td>
<td>0.50</td>
<td>$\overline{w}$</td>
<td>0.07</td>
</tr>
</tbody>
</table>

### Units Parameters

<table>
<thead>
<tr>
<th>Output</th>
<th>1</th>
<th>$z_N$</th>
<th>0.93</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative price of nontradables</td>
<td>1</td>
<td>$z_T$</td>
<td>0.48</td>
</tr>
<tr>
<td>Market tightness in goods markets</td>
<td>1</td>
<td>$\xi_d$</td>
<td>0.03</td>
</tr>
</tbody>
</table>
## Endogenously determined parameters: cross-section

<table>
<thead>
<tr>
<th>Target</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job duration for type 1</td>
<td>1.5 year</td>
<td>$\delta^1_n$</td>
<td>0.083</td>
</tr>
<tr>
<td>Job duration for type 3</td>
<td>5 year</td>
<td>$\delta^3_n$</td>
<td>0.025</td>
</tr>
<tr>
<td>Job duration for type 4</td>
<td>5 year</td>
<td>$\delta^4_n$</td>
<td>0.025</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>6%</td>
<td>$\delta^2_n$</td>
<td>0.048</td>
</tr>
<tr>
<td>Wealth Gini index</td>
<td>0.82</td>
<td>$\Pi^\epsilon_{1,4}$</td>
<td>0.0007</td>
</tr>
<tr>
<td>Earnings Gini index</td>
<td>0.64</td>
<td>$\Pi^\epsilon_{4,1}$</td>
<td>0.0156</td>
</tr>
<tr>
<td>Earning autocorrelation</td>
<td>0.91</td>
<td>$\Pi^\epsilon_{1,1}$</td>
<td>0.9660</td>
</tr>
<tr>
<td>Earning stdev</td>
<td>0.20</td>
<td>$\Pi^\epsilon_{2,2}$</td>
<td>0.9774</td>
</tr>
</tbody>
</table>
Lorenz Curve

Data

Model

0 0.2 0.4 0.6 0.8 1

Net worth
Housing asset
Financial asset

Huo & Ríos-Rull, NYU, Penn, UCL, CAERP
Financial Frictions, Asset Prices, & the Great Recession
Rochester Sept 15, 2015
Experiments: once and for all set of surprises in the environment

1. Over the next 4.5 months the down payment changes from 25% to 27.5% to 30% to 32.5% (to avoid having households with empty choice set).

2. The borrowing interest rate’s surcharge goes from zero to .3%.

3. Both at the same time.

4. The inverse process. Credit expansion.

- All of these with fixed and flexible wages.
Long Run Properties

• Typically like in all [?] - [?] - [?] - [?] type models, in the long run output and wealth end up being higher.

• But in our economies the transition is associated to a recession.
Experiment: gradual worsening of both $\lambda$ and borrowing cost

- Real output
- Unemployment
- Consumption
- Investment

Flexible wage
Fixed wage
Experiment: gradual worsening of both $\lambda$ and borrowing cost

Wealth

Debt

Housing price

Flexible wage

Fixed wage
Experiment: gradual worsening of both $\lambda$ and borrowing cost

TFP with total hours

Labor Productivity

Labor quality

TFP with total labor inputs

Flexible wage

Fixed wage
Experiment: gradual worsening of both $\lambda$ and borrowing cost

Change of labor quality in both pools when wages are flexible
Results: a boom and bust cycle
Results: a boom and bust cycle

Real output

Unemployment

Consumption

Investment
Results: a boom and bust cycle

Wealth

Debt

Housing price
Results: a boom and bust cycle
Conclusions

- We have a recession generated purely by increased difficulties to borrow on the part of households

- The recession comes together with
  - TFP loses
  - Drop in Housing prices (movements too sharp because of lack of house frictions)
  - Drop in Stock Market

- The literature is trying hard to get this ([?], [?]) with limited success.

- Still ways to go:
  - Foreclosures; slow housing frictions; Long term Mortgages.
  - Slow expanding export industries.
  - Model of banking cycles.
References


Figure: Aggregate Economy Response: with Price Rigidity
Price Rigidity in a Search Economy II

Average price

Price dispersion

Labor

Productivity

Flexible price
Rigid price
Facts on the last recession: IV

Debt to wealth

Debt to housing value

Huo & Ríos-Rull, NYU, Penn, UCL, CAERP

Financial Frictions, Asset Prices, & the Great Recession

Rochester Sept 15, 2015
Facts: Continued

Real output

Consumption

Investment
Facts: Continued

TFP with total hours

Labor productivity

Labor quality

TFP with total labor inputs
‘Real output’, ‘consumption’ and ‘investment’ are ‘Gross Domestic Product’, ‘Personal Consumption Expenditures’ and ‘Gross Private Domestic Investment’ from BEA.

‘TFP with total hours’ is calculated by Fernald (2012).

‘Labor productivity’ is total output divided by total hours.

‘Labor quality’ follows Aaronson and Sullivan (2001), which are extended by Bart Hobijn and Joyce Kwok (FRBSF).

‘TFP with total labor inputs’ is total output divided by the product of total hours and labor quality.

These variables shown at the beginning are deviations from their linear trends. These variables shown in the appendix have their values in 2007 q4 normalized to 100.
Experiment 1: gradual change of $\lambda$ from 0.75 to 0.675

- Real output
- Unemployment
- Consumption
- Investment

Flexible wage
Fixed wage
Experiment 1: gradual change of $\lambda$ from 0.75 to 0.675

Wealth

Debt

Housing price

Flexible wage

Fixed wage
Experiment 1: gradual change of $\lambda$ from 0.75 to 0.675

TFP with total hours

Labor Productivity

Labor quality

TFP with total labor inputs

Flexible wage

Fixed wage
Experiment 2: gradual change of borrowing cost from 0 to 0.3%
Experiment 2: gradual change of borrowing cost from 0 to 0.3%

### Graphs

- **Wealth**
  - Blue line: Flexible wage
  - Red dotted line: Fixed wage

- **Debt**
  - Blue line: Flexible wage
  - Red dotted line: Fixed wage

- **Housing price**
  - Blue line: Flexible wage
  - Red dotted line: Fixed wage
Experiment 2: gradual change of borrowing cost from 0 to 0.3%