Financial Frictions, Asset Prices, and the Great Recession

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Facts on the last recession: I

Real output

Unemployment

Consumption

Investment

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
Facts on the last recession: III

Note: Figures show percentage deviation from a linear trend.
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.
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- Total factor productivity dropped.
Objective: When can recessions be triggered by worse financial conditions faced by households?
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1. Real frictions that make difficult to switch from production of consumption goods to exports or investment. Labor market frictions that limit wage adjustments.

2. Households differing in wealth and job market prospects.

3. Asset prices respond to market conditions: Both housing prices and the Stock Market are Endogenous.

4. A financial system used widely by not-too-rich households to buy houses (loans have to be collateralized) which are inferior goods and not wanted by the super-rich.

5. Frictions in the goods market generate movements in measured TFP. We extend [Huo and Ríos-Rull(2013a)] and [Huo and Ríos-Rull(2013b)] [Bai, Ríos-Rull, and Storesletten(2011)] [Petrosky-Nadeau and Wasmer(2011)] in various ways to include a production sector and asset prices that allows us to talk about the U.S. recession.
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Findings

A recession can be triggered by financial shocks to households. It shares most of the features of the Great Recession. Large reductions in assets (housing and stocks) prices. Lower than the data due to inexistence of default, foreclosures, and adjustment costs in house purchases.
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Model
Households: Preferences

- Continuum of households that live forever ($\beta$), are subject to uninsurable idiosyncratic and aggregate shocks.
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- H'holds care about quantities and number of varieties of nontradables.

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

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

- $\Psi^d(Q^g)$: Probability (per search unit) of finding a variety.
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- Households also like tradables and housing and dislike goods searching

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

- Household skill type is $\epsilon$, follows a Markov chain $\Gamma_{\epsilon,\epsilon'}$. Moves slowly and accommodates opportunities to get rich.
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  - 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) ([Fang and Nie(2013)]).
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- 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.
Production: two sectors tradables and nontradables.

- Nontradables

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- Monopolistic firms, each one producing a different variety. Each firm/variety has many locations, and each location has its own production function. Labor can be partially reallocated to accommodate demand differences across locations.

- Firms post prices before the location is filled.

Tradables (standard)

- Competitive.
- (Large) Adjustment costs to both capital and labor.
- Its output is used for exports, investment, and (part of) consumption.
- Decreasing returns.
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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.
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  - 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:

\[ N = N + N \]

Same job finding probability across types:

\[ \Phi_e = V_1 - N \]

Wages are determined via the following formula

\[ \log w - \log w = \varepsilon w \left( \log Y - \log Y \right) \]

It simplifies things. 

[Gornemann, Kuester, and Nakajima(2012)].
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- Employment: \( N = N_N + N_T \).
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Assets markets: Financial assets and houses

Total housing is in fixed supply. Negative financial assets ($b' < 0$) are (undefaultable) mortgages. Its interest rate $1q(θ, b')$ is predetermined at borrowing time,

$$q(θ, b') = \begin{cases} 1, & \text{if } b' \geq 0 \\ 1 + r^* - ς(θ), & \text{if } b' < 0 \end{cases}$$

Mortgages have to be collateralized by housing: if $b' < 0$ then

$$q(θ, b') |b'| \leq [1 - λ(θ)] p_h(S)$$

Positive financial assets ($b > 0$) are shares of a mutual fund. Its return is stochastic. Possible capital gains and loses.

$$R(S, S', b) = \begin{cases} 1 + r(S, S'), & \text{if } b \geq 0 \\ 1, & \text{if } b < 0 \end{cases}$$
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  - The return is
    \[
    R(S, S', b) = \begin{cases} 
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    \end{cases}
    \]
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

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

\[ \beta \sum_{e', \epsilon, e' | e, \epsilon} \Pi^{\theta}_{\theta, \theta'} \Pi^w_{e', \epsilon} \Pi^\epsilon_{\epsilon, e'} V[S', \epsilon', e', a'(S', b, h)] \]
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subject to

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

BC
Households’ problem

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\[ \beta \sum_{\epsilon', e', \theta'} \Pi_{\theta, \theta'}^{I_N} \Pi_{\epsilon, \epsilon'}^{w}(S') \Pi_{\epsilon, \epsilon'}^{\nu} V[S', \epsilon', e', a'(S', b, h)] \]

subject to

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BC

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

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\[ q(\theta, b) b \geq -\lambda(\theta) p_h(S) h \]

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\beta \sum_{\epsilon', e', \theta'} \Pi_{\theta, \theta'} \Pi_{e'|e, \epsilon}(S') \Pi_{\epsilon, \epsilon'} V[S', \epsilon', e', a'(S', b, h)]
\]

subject to

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

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a'(S', b, h) = p_h(S') h + R(S, S', b) b \quad \text{AA}
\]

\[
q(\theta, b) b \geq -\lambda(\theta) p_h(S) h \quad \text{FC}
\]

\[
I_N = d \Psi^d [Q^g(S)] \quad \text{SC}
\]
Households’ problem

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

SC

\[ S' = G(S, \epsilon') \]
Nontradable firms’ problem

- At each location, the production function is

\[ F^N(k, \ell_1, \ell_2) = z_N k^{\alpha_0} \ell_1^{\alpha_1} \ell_2^{\alpha_2} \]

- \( k \) and \( \ell_1 \) are pre-installed. \( \ell_2 \) is variable to meet different demands.

- The demand function is given by

\[ c(p_i, S, x) = \left[ \frac{p_i}{p(S)} \right]^{1-\rho} c_N(S, x) \]

- When a shopper wants to buy \( c \) units of goods at a location, the amount of variable labor \( \ell_2 \) needed to produce \( c \) is

\[ f^\ell(c, k, \ell_1) = \left( c^{-1} z_N k^{\alpha_0} \ell_1^{\alpha_1} \right)^{-\frac{1}{\alpha_2}} \]

- At the posted price \( p_i \), the total variable labor needed is

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

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

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

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

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

\[ S' = G(S, \theta') \text{ RE} \]
Tradable firms’ problem

\[ \Omega_T^T(S, k, n) = \max_{i, v} F_T^T(k, \ell) - w(S)\ell - i - \kappa v - \phi_T^{T,n}(n', n) \]

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

subject to

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

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

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

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

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

- 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

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

- 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

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

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

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

Engel Curve: consumption vs housing
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

\[ \phi^N(i, k) = \varepsilon_N^N \left( \frac{i}{k} - \delta_k \right)^2 k \]

- Capital and employment adjustment cost in the tradable goods sector

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

- 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, $\sigma^1_h$</td>
<td>2.0</td>
</tr>
<tr>
<td>Risk aversion for housing, $\sigma^2_h$</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>$\bar{w}$</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

Net worth
Housing asset
Financial asset

Model

Huo & Ríos-Rull, UMN, Mpls Fed, CAERP
Financial Frictions, Asset Prices, & the Great Recession
LBS Nov 13 2014
Experiments: once and for all set of surprises in the environment

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).

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

Both at the same time.

The inverse process. Credit expansion.

• All of these with fixed and flexible wages.
Experiments: once and for all set of surprises in the environment

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Long Run Properties

- Typically like in all [Aiyagari(1994)] - [Bewley(1986)] - [Huggett(1993)] - [Imrohoroglu(1989)] type models, in the long run output and wealth end up being higher.
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- 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
Experiment: gradual improvement of $\lambda$ from 0.75 to 0.825

- Real output
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Experiment: gradual improvement of $\lambda$ from 0.75 to 0.825
Experiment 5: More flexible wage schedule

Flexible wage $\epsilon_w = 0.45$  
Flexible wage $\epsilon_w = 1$
Experiment 5: More flexible wage schedule

Flexible wage $\epsilon_w = 0.45$  Flexible wage $\epsilon_w = 1$
Experiment 5: More flexible wage schedule

Flexible wage $\epsilon_w = 0.45$

Flexible wage $\epsilon_w = 1$
Results: a boom and bust cycle

Loan to value ratio $\lambda$
Results: a boom and bust cycle
Results: a boom and bust cycle

Wealth

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Housing price
Results: a boom and bust cycle

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Labor quality

TFP with total labor inputs
Conclusions

We have a recession generated purely by increased difficulties to borrow on the part of households. The recession comes together with TFP loses. A drop in Housing prices (movements too sharp because of lack of house frictions) and a drop in Stock Market.

**Conclusions**

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- 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 ([Midrigan and Philippon(2011)], [Guerrieri and Lorenzoni(2009)]) with limited success.

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

Real output

Consumption

Investment

Huo & Ríos-Rull, UMN, Mpls Fed, CAERP
Financial Frictions, Asset Prices, & the Great Recession
LBS Nov 13 2014
Facts: Continued

TFP with total hours

Labor productivity

Labor quality

TFP with total labor inputs

Huo & Ríos-Rull, UMN, Mpls Fed, CAERP
Financial Frictions, Asset Prices, & the Great Recession
LBS Nov 13 2014
Facts: Continued

- ‘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

+ 

![Graphs showing changes in real output, unemployment, consumption, and investment under flexible and fixed wage scenarios.](image-url)
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%

Wealth

Debt

Housing price

Flexible wage

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