Financial Frictions, Asset Prices, and the Great Recession

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First Version April 2013
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
Facts on the last recession: III

Note: Figures show percentage deviation from a linear trend.

Huo & Ríos-Rull, UMN, Mpls Fed, CAERP
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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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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.
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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.
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.

$H'\text{holds care about quantities and number of varieties of nontradables.}$

$c_N = (\int I_N^{0} c_1 \rho N_i d_i) \rho$

Under equal consumption of each variety:

$c_N I = \int I_N^{0} c_1 \rho N_i d_i$

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

$I_N = d \Psi(Q_g)$

$\Psi(Q_g)$: Probability (per search unit) of finding a variety.

Households also like tradables and housing and dislike goods searching.

$[c_A(c_N I \rho N, c_T, h, d)]$
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\[ u [c_A(c_N \, I_N^\rho, c_T), \, h, \, d] \]
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- Household skill type is $\epsilon$, follows a Markov chain $\Gamma_{\epsilon,\epsilon'}$. Moves slowly and accommodates opportunities to get rich.
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- Households either have a job $e = 1$ or not $e = 0$.
  - Type-dependent exogenous job destruction rate $\delta^n_\epsilon$.

- 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) ([Fang and Nie(2013)])

- 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.
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  - Decreasing returns.
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: \( N = N_N + N_T \).

Same job finding probability across types: \( \Phi = V_1 - N \).

Wages are determined via the following formula:

\[
\log w - \log w = \varepsilon_w (\log Y - \log Y)
\]

It simplifies things. [Gornemann, Kuester, and Nakajima (2012)].
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Assets markets: Financial assets and houses

Total housing $H$ is in fixed supply. Negative financial assets ($b' < 0$) are (undefaultable) mortgages. Its interest rate $q$ is predetermined at borrowing time, $q(\theta, b') = \begin{cases} 1, & \text{if } b' \geq 0 \\ 1 + r^* - \varsigma(\theta), & \text{if } b' < 0 \end{cases}$

Mortgages have to be collateralized by housing: if $b' < 0$ then $q(\theta, b') |_{b'} | \leq [1 - \lambda(\theta)] p_h(S_h)$

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

\[ V(S, \epsilon, e, a) = \max_{c_{N,i}, c_{T}, I_{N}, h, d} u(c_{A}, h, d) + \]
\[ \beta \sum_{\epsilon', \epsilon'} \Pi_{\theta, \theta'}^{\epsilon'} \Pi_{e'}^{\epsilon} |e, \epsilon(S') \Pi_{\epsilon, \epsilon'}^{\epsilon} V[S', \epsilon', e', a'(S', b, h)] \]
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\[ \beta \sum_{\epsilon', e', \theta'} \Pi_{\theta, \theta'}^{\epsilon} \Pi_{\epsilon'}^{w} |e, \epsilon(S') \Pi_{\epsilon, \epsilon'}^{\epsilon} V[S', \epsilon', e', a'(S', b, h)] \]

subject to

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

BC
Households’ problem

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subject to

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

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

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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'} \Pi_{e'|e, \epsilon} (S') \Pi_{\epsilon, \epsilon'} V[S', \epsilon', e', a'(S', b, h)]
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a'(S', b, h) = p_h(S')h + R(S, S', b)b \\
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AA

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

FC
Households’ problem

\[ V(S, \epsilon, e, a) = \max_{c_{N,i}, c_T, I_N, h, d} \left( u(c_A, h, d) + \beta \sum_{\epsilon', e'} \Pi^\theta_{\epsilon, \epsilon'} \Pi^{w}_{\epsilon, \epsilon'} V[S', \epsilon', e', a'(S', b, h)] \right) \]

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

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

subject to

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

FC

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

SC

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

RE
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

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

- 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

\[
\Omega^N(S, k, n) = \max_{i, v, p_i} \Psi^f[Q^g(S)] p_i \int c(p_i, S, \epsilon, e, a) \, dx - w(S) \ell - i - \kappa v \\
+ \sum_{\theta', \theta} \Pi_{\theta, \theta'} \frac{\Omega^N(S', k', n')}{1 + r^*} 
\]

subject to

\[
\ell_2 \geq \Psi^f[Q^g(S)] \int f^\ell[c(p_i, S, x), k, \ell_1] \frac{d(x, S)}{D(S)} \\
\ell_1 + \ell_2 = n \bar{e}(S) \\
k' = (1 - \delta_k)k + i - \phi^N(k, i) \\
n' = [1 - \bar{\delta}_n(S)]n + v \\
S' = G(S, \theta')
\]
Tradable firms’ problem

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

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

subject to

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

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

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

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

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

- Rate of return to the mutual fund satisfies

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

- Wage satisfies

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

- 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

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

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

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

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

- 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, $\sigma^1_h$</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, $\hat{h}$</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>

<table>
<thead>
<tr>
<th>Units Parameters</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>1</td>
<td>(z_N)</td>
<td>0.93</td>
</tr>
<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>$\Pi_{1,4}^\epsilon$</td>
<td>0.0007</td>
</tr>
<tr>
<td>Earnings Gini index</td>
<td>0.64</td>
<td>$\Pi_{4,1}^\epsilon$</td>
<td>0.0156</td>
</tr>
<tr>
<td>Earning autocorrelation</td>
<td>0.91</td>
<td>$\Pi_{1,1}^\epsilon$</td>
<td>0.9660</td>
</tr>
<tr>
<td>Earning stdev</td>
<td>0.20</td>
<td>$\Pi_{2,2}^\epsilon$</td>
<td>0.9774</td>
</tr>
</tbody>
</table>
Lorenz Curve

Data

Model

- Net worth
- Housing asset
- Financial asset

Huo & Ríos-Rull, UMN, Mpls Fed, CAERP
Financial Frictions, Asset Prices, & the Great Recession
NYU, Th Sept 18 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.
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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
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
Experiment: gradual improvement of $\lambda$ from 0.75 to 0.825

![Graphs showing Wealth, Debt, and Housing price with Flexible and Fixed wage scenarios](image-url)
Experiment: gradual improvement of $\lambda$ from 0.75 to 0.825

TFP with total hours

Labor Productivity

Labor quality

TFP with total labor inputs

Flexible wage

Fixed wage
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

Real output

Unemployment

Consumption

Investment
Results: a boom and bust cycle

Wealth

Debt

Housing price
Results: a boom and bust cycle

TFP with total hours

Labor Productivity

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 losses, a drop in housing prices (movements too sharp because of lack of house frictions), and a 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.
Conclusions

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

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  - Model of banking cycles.


Facts on the last recession: IV

![Graphs showing Debt to wealth and Debt to housing value over the years 2004 to 2012.](image)
Facts: Continued

### Real output

- 1980: 40
- 1985: 50
- 1990: 60
- 1995: 70
- 2000: 80
- 2005: 90
- 2010: 100

### Consumption

- 1980: 20
- 1985: 40
- 1990: 60
- 1995: 80
- 2000: 100
- 2005: 120
- 2010: 140

### Investment

- 1980: 0
- 1985: 20
- 1990: 40
- 1995: 60
- 2000: 80
- 2005: 100
- 2010: 120
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

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 vs. 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%

TFP with total hours

Labor Productivity

Labor quality

TFP with total labor inputs

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