

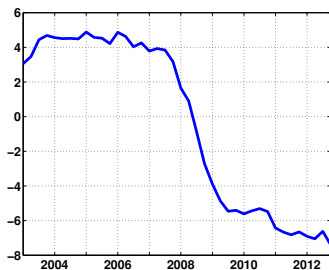
Financial Frictions, Asset Prices, and the Great Recession

Zhen Huo and José-Víctor Ríos-Rull

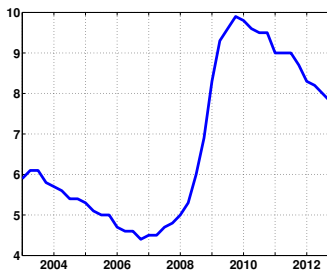
University of Minnesota, Federal Reserve Bank of Minneapolis, CAERP, CEPR, NBER

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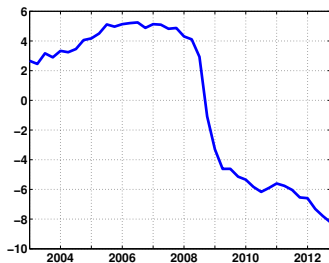
Facts on the last recession: I



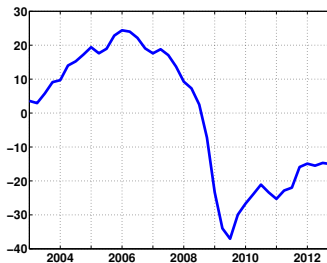
Real output



Unemployment



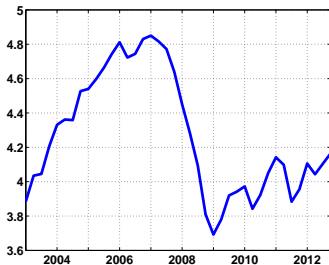
Consumption



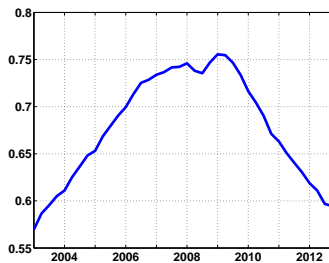
Investment

Note: Except for unemployment, figures show percentage deviation from a linear trend.

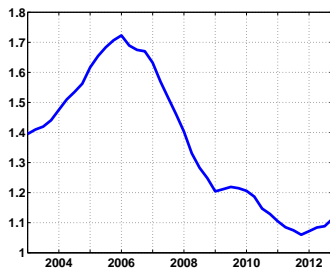
Facts on the last recession: II



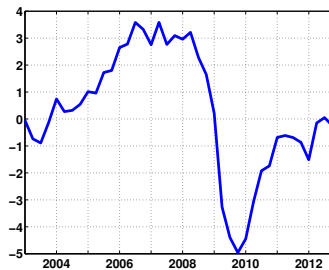
Wealth to output



Debt to output



Housing value to output



Labor Quality adjusted Productivity

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: When can recessions be triggered by worse financial conditions faced by households?

- 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) 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.

Model

Households: Preferences

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

$$c_N = \left(\int_0^{I_N} c_{Ni}^{\frac{1}{\rho}} di \right)^{\rho}$$

- Under equal consumption of each variety: $c_N I_N^{\rho} = \left[\int_0^{I_N} c_{Ni}^{\frac{1}{\rho}} di \right]^{\rho}$
- 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.
- 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 ϵ , 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 δ_n^ϵ .
 - 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.

Production: two sectors tradables and nontradables.

- **Nontradables**

- 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.

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

$$\log w - \log \bar{w} = \varepsilon_w (\log Y - \log \bar{Y})$$

It simplifies things.

Gornemann, Kuester, and Nakajima (2012).

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 $\frac{1}{q}$ is predetermined at borrowing time,

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

- Mortgages have to be collateralized by housing

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

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

$$R(S, S', b) = \begin{cases} 1 + r(S, S'), & \text{if } b \geq 0 \\ 1, & \text{if } b < 0. \end{cases}$$

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

$$V(S, \epsilon, e, a) = \max_{c_{N,i}, c_T, I_N, h, d} u(c_A, h, d) + \beta \sum_{\epsilon', e', \theta'} \Pi_{\theta, \theta'}^\theta \Pi_{e'|e, \epsilon}^w(S') \Pi_{\epsilon, \epsilon'}^\epsilon V[S', \epsilon', e', a'(S', b, h)]$$

subject to

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

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

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

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

$$S' = G(S, \theta')$$

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 ℓ_1 are pre-installed. ℓ_2 is variable to meet different demands.
- The demand function is given by $c(p_i, S, x) = \left[\frac{p_i}{p(S)} \right]^{\frac{\rho}{1-\rho}} c_N(S, x)$
- When a shopper wants to buy c units of goods at a location, the amount of variable labor ℓ_2 needed to produce c is

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

- 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

$$\Omega^N(S, k, n) = \max_{\substack{i, v, p_i \\ \ell_1, \ell_2}} \Psi^f[Q^g(S)] p_i \int c(p_i, S, \epsilon, e, a) dx - w(S)\ell - i - \kappa v \\ + \sum_{\theta'} \Pi_{\theta, \theta'}^{\theta} \frac{\Omega^N(S', k', n')}{1 + r^*}$$

subject to

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

$$\ell_1 + \ell_2 = n \bar{\epsilon}(S) \quad \text{SL}$$

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

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

$$S' = G(S, \theta') \quad \text{RE}$$

Tradable firms' problem

$$\Omega^T(S, k, n) = \max_{i, v} F^T(k, \ell) - w(S)\ell - i - \kappa v - \phi^{T, n}(n', n) \\ + \sum_{\theta'} \Pi_{\theta, \theta'}^{\theta} \frac{\Omega^T(S', k', n')}{1 + r^*}$$

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

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

- 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

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

- The law of motion $G(S)$ is consistent with households' decisions and employment dynamics.

Mapping the Model to Data

Functional forms

- Preferences

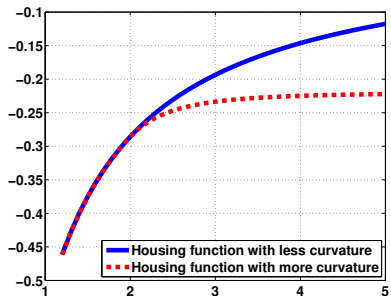
$$u(c_A, h, d) = \frac{1}{1 - \sigma_c} \left(c_A - \xi_d \frac{d^{1+\gamma}}{1 + \gamma} \right)^{1 - \sigma_c} + v(h)$$

- where there is an Armington aggregator for consumption

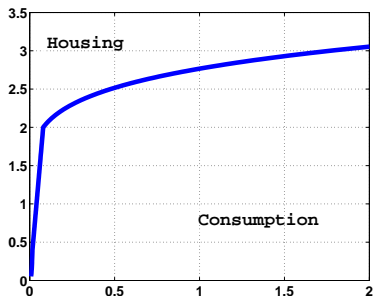
$$c_A = \left[\omega (c_N I_N^\rho)^{\frac{\eta-1}{\eta}} + (1 - \omega) c_T^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

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

$$v(h) = \begin{cases} \frac{\xi_h}{1 - \sigma_h^1} (h + \underline{h}_1)^{1 - \sigma_h^1}, & \text{if } h < \hat{h} \\ \frac{\xi_h}{1 - \sigma_h^2} (h + \underline{h}_2)^{1 - \sigma_h^2}, & \text{if } h \geq \hat{h}. \end{cases}$$



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

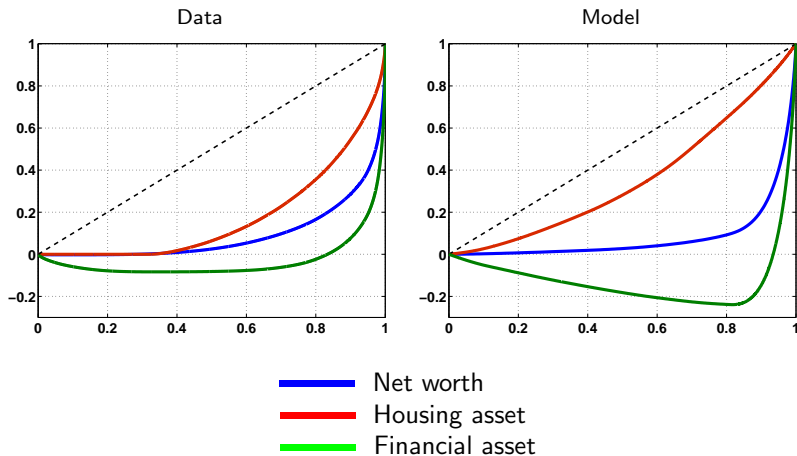
- A period is half a quarter.

Parameter	Value
Risk aversion for consumption, σ_c	2.0
Risk aversion for housing, σ_h^1	2.0
Risk aversion for housing, σ_h^2	10.0
Curvature of shopping, γ	1.5
Elasticity of substitution bw tradables and nontradables, η	0.80
Cutoff value for housing utility, \hat{h}	1.4
Price markup, ρ	1.1
Loan to value ratio, λ	0.75
Interest rate for international bonds, r^*	4%

Endogenously determined parameters: aggregate

Target	Value	Parameter	Value
Wealth to output ratio	4.70	β	0.98
Housing value to output ratio	1.67	ξ_h	0.95
Debt to output ratio	0.75	ϵ_4	30.77
Share of tradables	0.30	ω	0.95
Occupancy Rate	0.81	ν	0.81
Capital to output ratio	2.00	δ_k	0.01
Labor Share in nontradables	0.64	α_0	0.27
$\alpha_1 = \alpha_2$	—	α_1	0.36
Labor Share in tradables	0.66	θ_1	0.66
$1.4\theta_0 + \theta_1 = 1$	—	θ_0	0.23
Vacancy cost to output ratio	0.02	κ	0.42
Home production to lowest earning ratio	0.50	\bar{w}	0.07
Units Parameters			
Output	1	z_N	0.93
Relative price of nontradables	1	z_T	0.48
Market tightness in goods markets	1	ξ_d	0.03

Target	Value	Parameter	Value
Job duration for type 1	1.5 year	δ_n^1	0.083
Job duration for type 3	5 year	δ_n^3	0.025
Job duration for type 4	5 year	δ_n^4	0.025
Unemployment rate	6%	δ_n^2	0.048
Wealth Gini index	0.82	$\Pi_{1,4}^\epsilon$	0.0007
Earnings Gini index	0.64	$\Pi_{4,1}^\epsilon$	0.0156
Earning autocorrelation	0.91	$\Pi_{1,1}^\epsilon$	0.9660
Earning stdev	0.20	$\Pi_{2,2}^\epsilon$	0.9774



Experiments: once and for all set of surprises in the environment

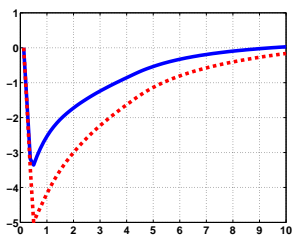
- 1 Over the next 4.5 months the down payment changes from 25% to 27.5% to 30% to 32.5% (to avoid having households with empty choice set).
 - 2 The borrowing interest rate's surcharge goes from zero to .3%.
 - 3 Both at the same time.
 - 4 The inverse process. Credit expansion.
- All of these with fixed and flexible wages.

Long Run Properties

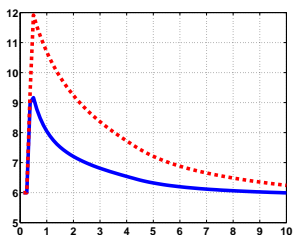
- Typically like in all Aiyagari (1994) - Bewley (1986) - Huggett (1993) - Imrohoroglu (1989) type models, in the long run output and wealth end up being higher.

- But in our economies the transition is associated to a recession.

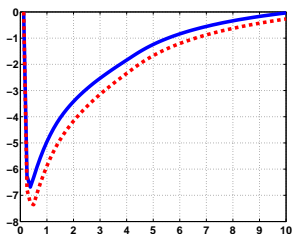
Experiment : gradual worsening of both λ and borrowing cost



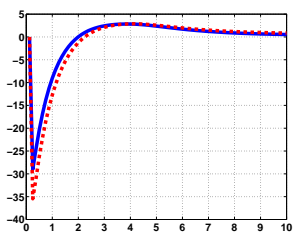
Real output



Unemployment



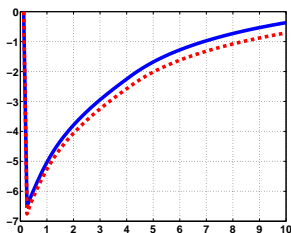
Consumption



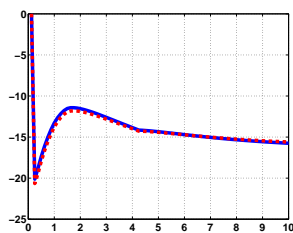
Investment

— Flexible wage - - - Fixed wage

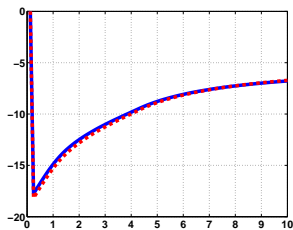
Experiment: gradual worsening of both λ and borrowing cost



Wealth



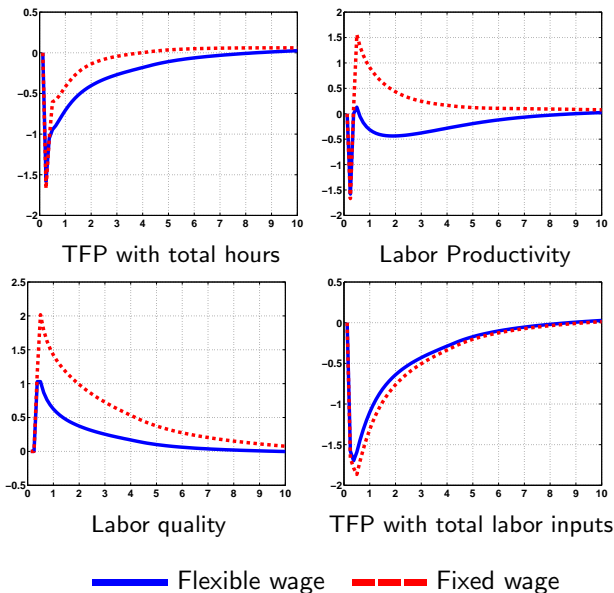
Debt



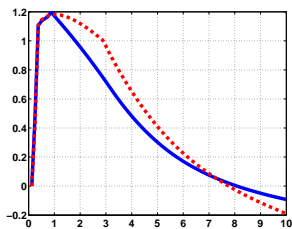
Housing price

— Flexible wage - - - Fixed wage

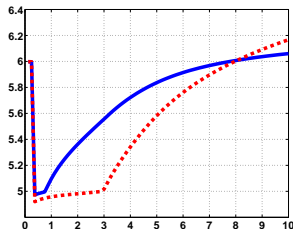
Experiment: gradual worsening of both λ and borrowing cost



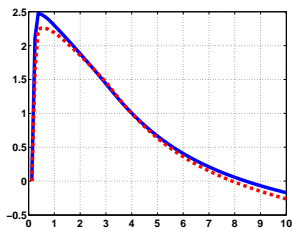
Experiment: gradual improvement of λ from 0.75 to 0.825



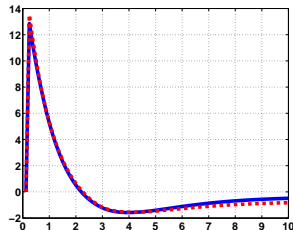
Real output



Unemployment



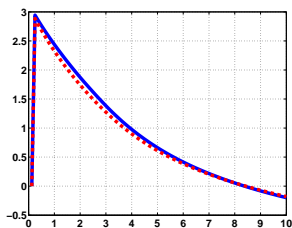
Consumption



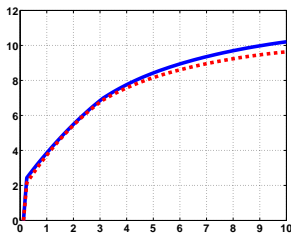
Investment

— Flexible wage - - - Fixed wage

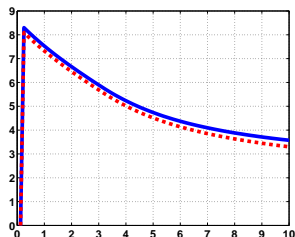
Experiment: gradual improvement of λ from 0.75 to 0.825



Wealth



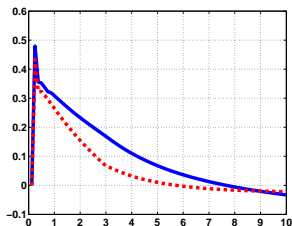
Debt



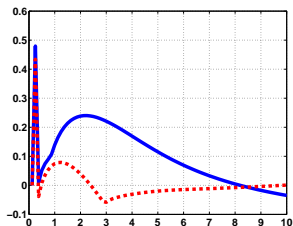
Housing price

— Flexible wage - - - Fixed wage

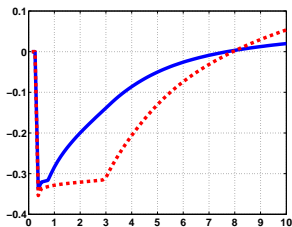
Experiment: gradual improvement of λ from 0.75 to 0.825



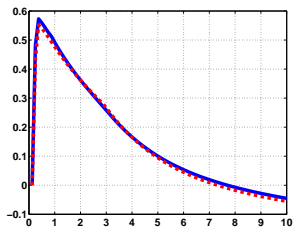
TFP with total hours



Labor Productivity



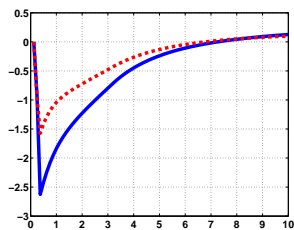
Labor quality



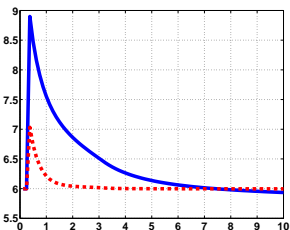
TFP with total labor inputs

— Flexible wage - - - Fixed wage

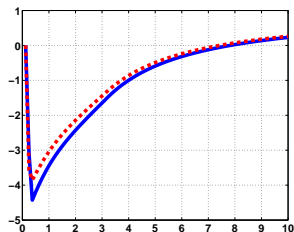
Experiment 5: More flexible wage schedule



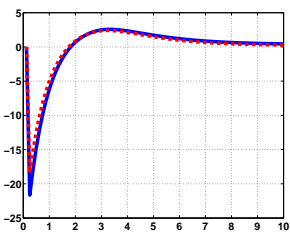
Real output



Unemployment



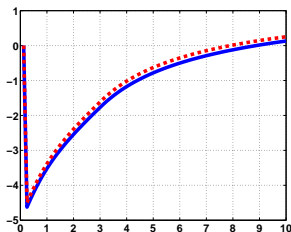
Consumption



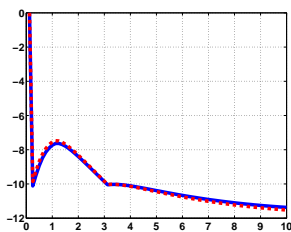
Investment

— Flexible wage $\epsilon_w = 0.45$ - - - Flexible wage $\epsilon_w = 1$

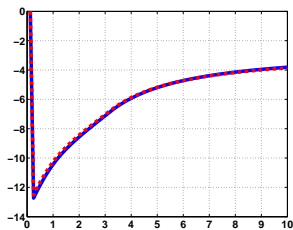
Experiment 5: More flexible wage schedule



Wealth



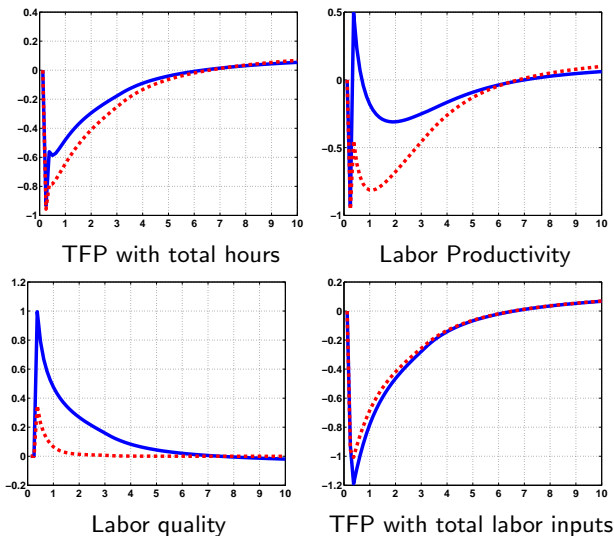
Debt



Housing price

— Flexible wage $\epsilon_w = 0.45$ - - - Flexible wage $\epsilon_w = 1$

Experiment 5: More flexible wage schedule



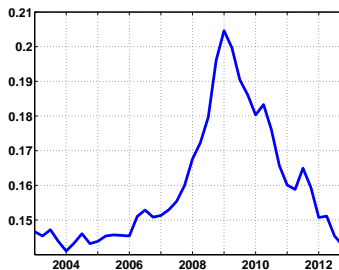
— Flexible wage $\epsilon_w = 0.45$ - - - Flexible wage $\epsilon_w = 1$

Conclusions

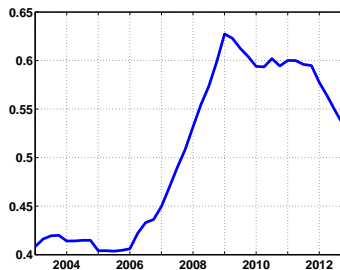
- We have a recession generated purely by increased difficulties to borrow on the part of households
- The recession comes together with
 - TFP loses
 - Drop in Housing prices (movements too sharp because of lack of house frictions)
 - Drop in Stock Market
- The literature is trying hard to get this (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.

References

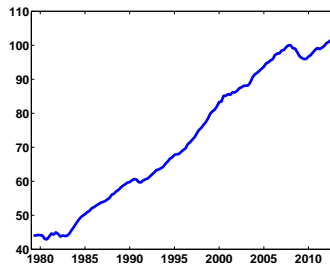
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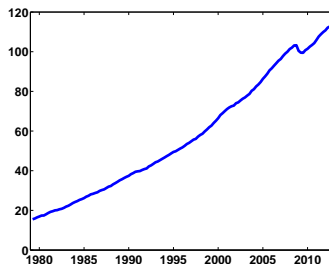
Debt to wealth



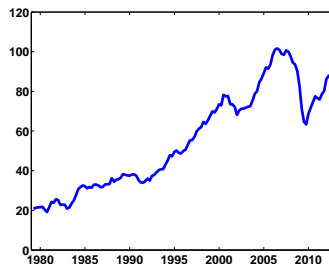
Debt to housing value



Real output



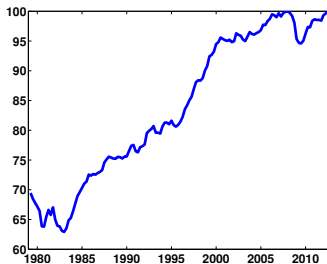
Consumption



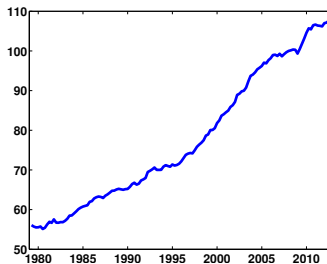
Investment

Facts: Continued

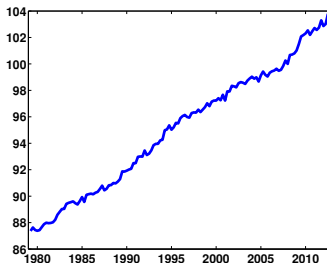
[Return](#)



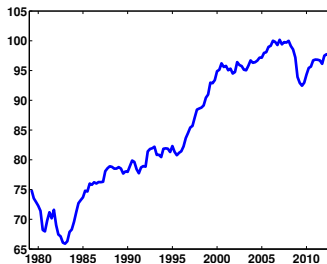
TFP with total hours



Labor productivity



Labor quality



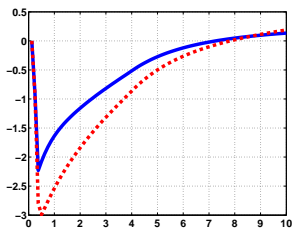
TFP with total labor inputs

Facts: Continued

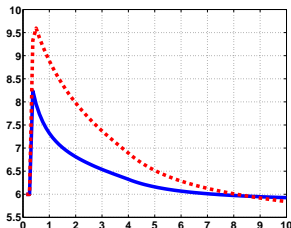
- 'Real output', 'consumption' and 'investment' are 'Gross Domestic Product', 'Personal Consumption Expenditures' and 'Gross Private Domestic Investment' from BEA.
- 'TFP with total hours' is calculated by Fernald (2012).
- 'Labor productivity' is total output divided by total hours.
- 'Labor quality' 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 λ from 0.75 to 0.675

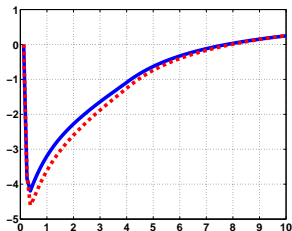
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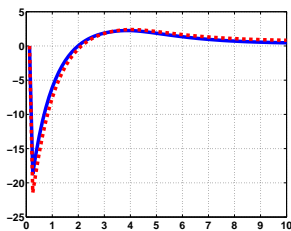
Real output



Unemployment



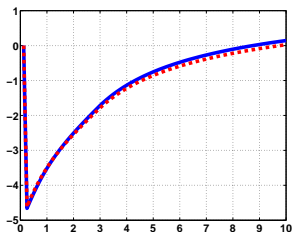
Consumption



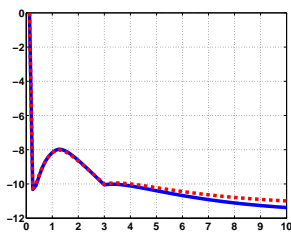
Investment

— Flexible wage - - - Fixed wage

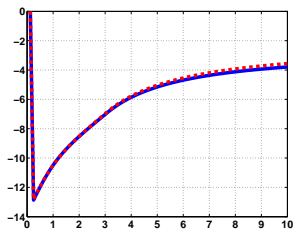
Experiment 1: gradual change of λ from 0.75 to 0.675



Wealth



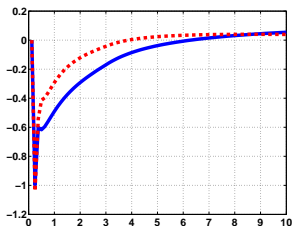
Debt



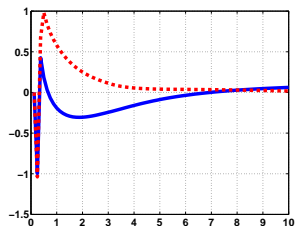
Housing price

— Flexible wage - - - Fixed wage

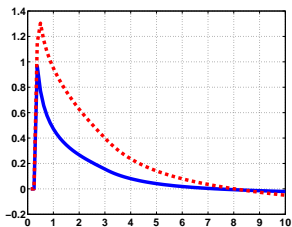
Experiment 1: gradual change of λ from 0.75 to 0.675



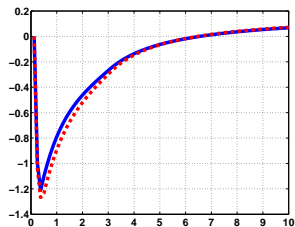
TFP with total hours



Labor Productivity



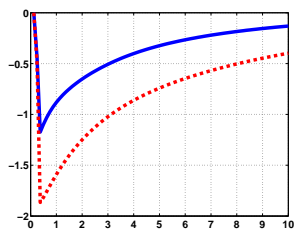
Labor quality



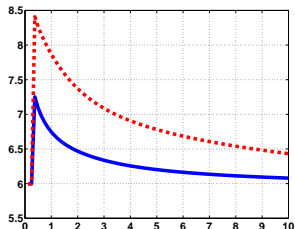
TFP with total labor inputs

— Flexible wage - - - Fixed wage

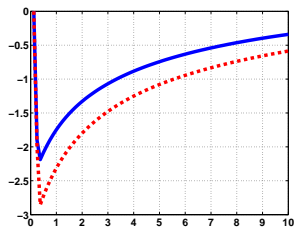
Experiment 2: gradual change of borrowing cost from 0 to 0.3%



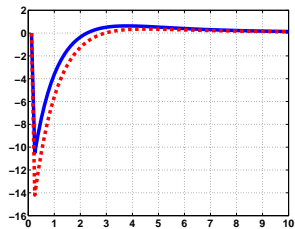
Real output



Unemployment



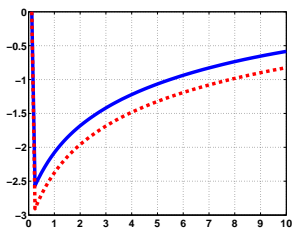
Consumption



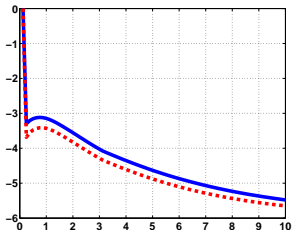
Investment

— Flexible wage - - - Fixed wage

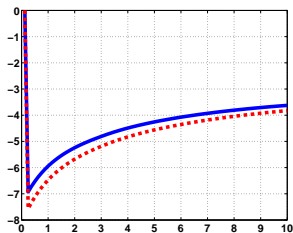
Experiment 2: gradual change of borrowing cost from 0 to 0.3%



Wealth



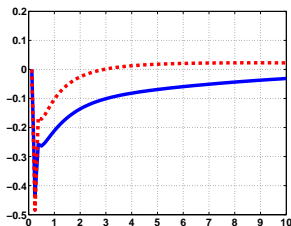
Debt



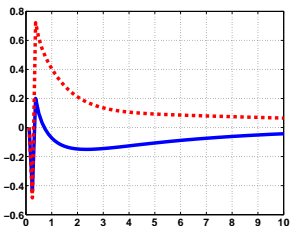
Housing price

— Flexible wage - - - Fixed wage

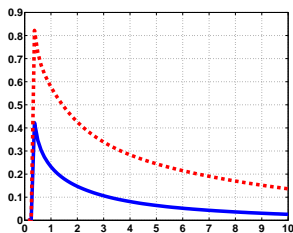
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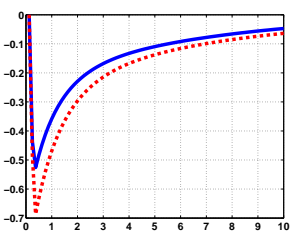
TFP with total hours



Labor Productivity



Labor quality



TFP with total labor inputs

— Flexible wage - - - Fixed wage