Financial Frictions, Asset Prices, and the Great Recession

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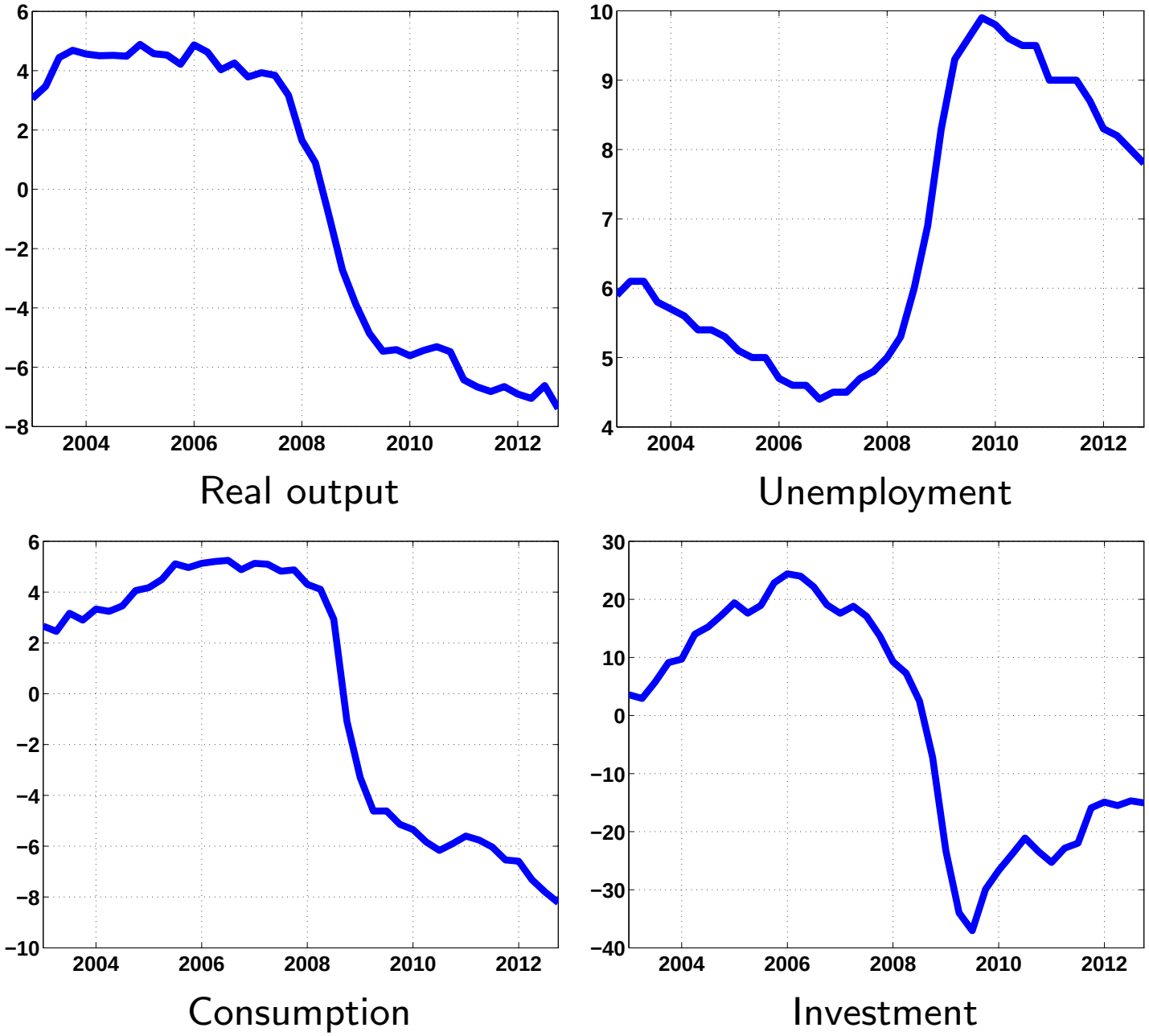
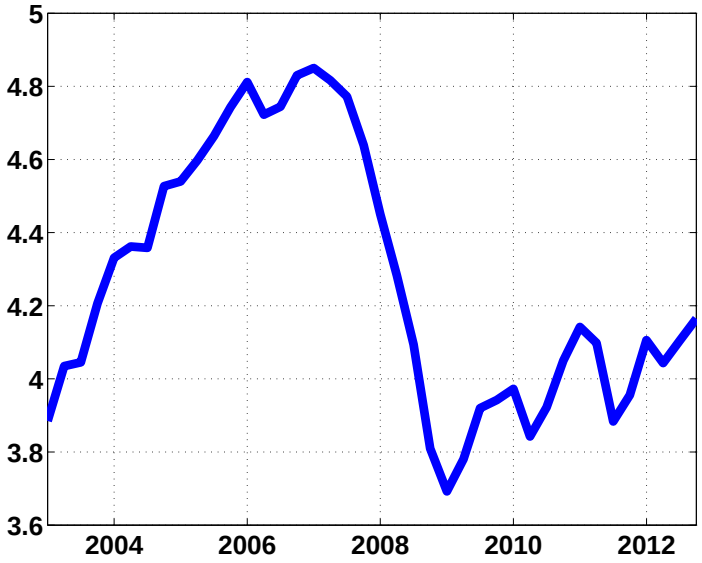
Very Preliminary

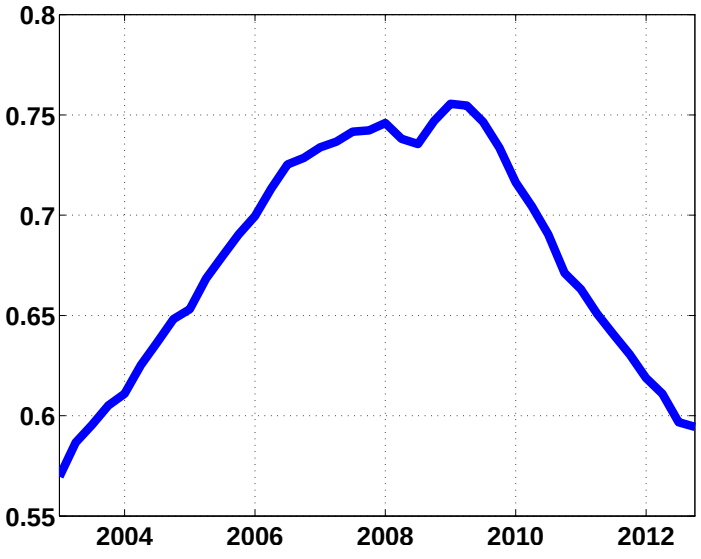
Facts on the last recession: I



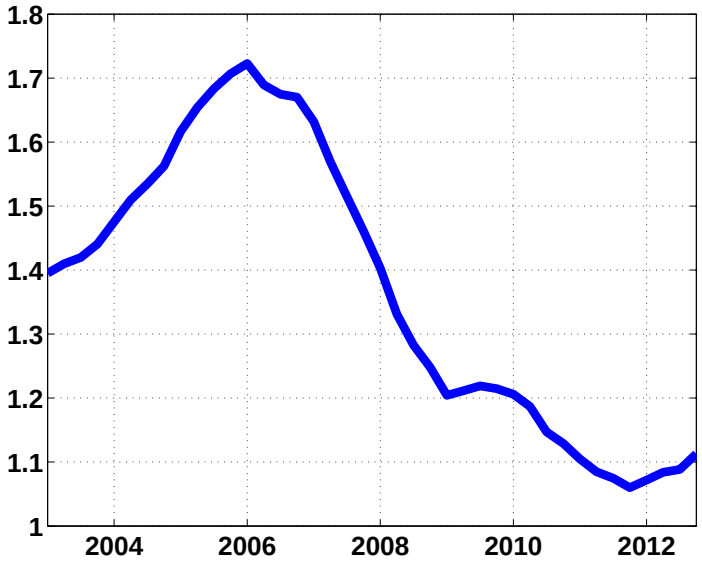
Facts on the last recession: II



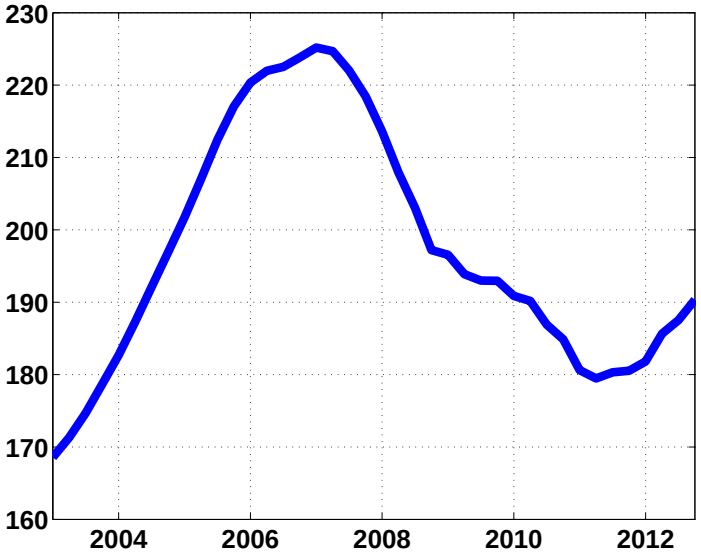
Wealth to output



Debt to output

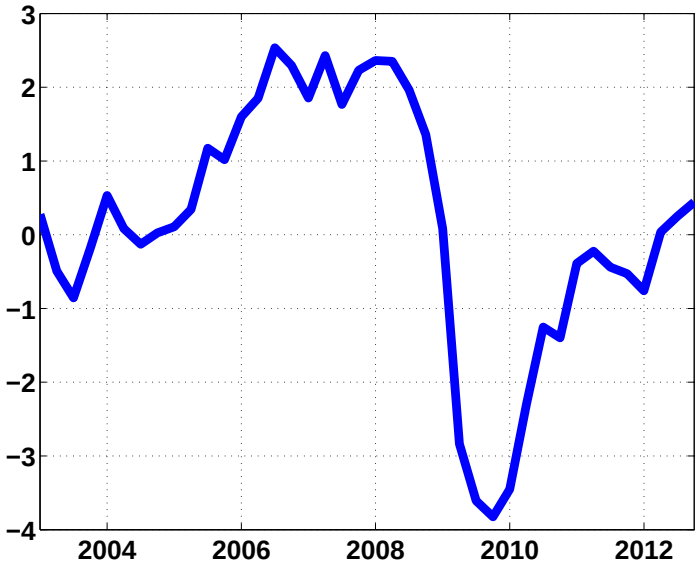


Housing value to output

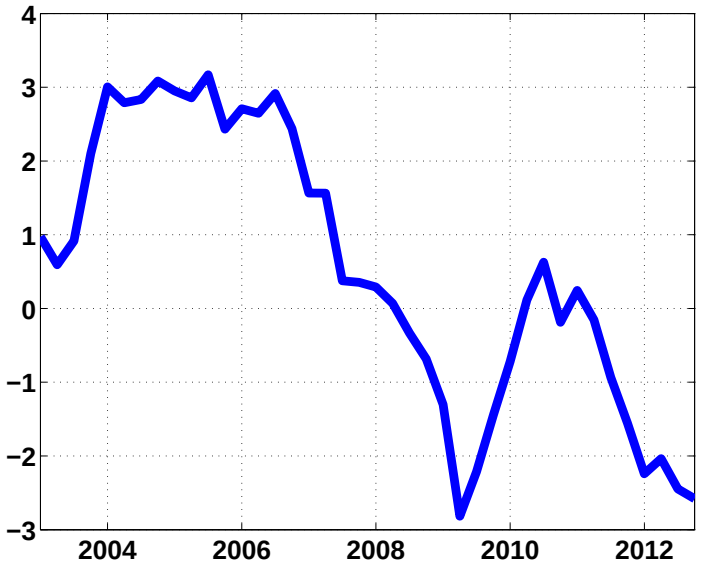


Housing price index

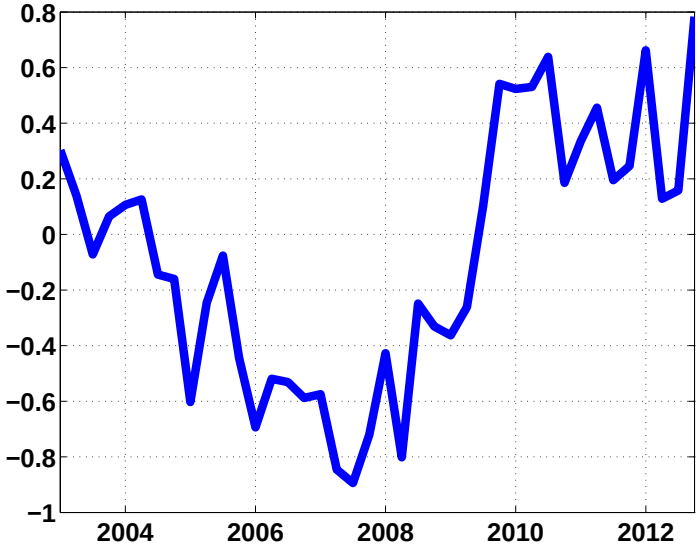
Facts on the last recession: III



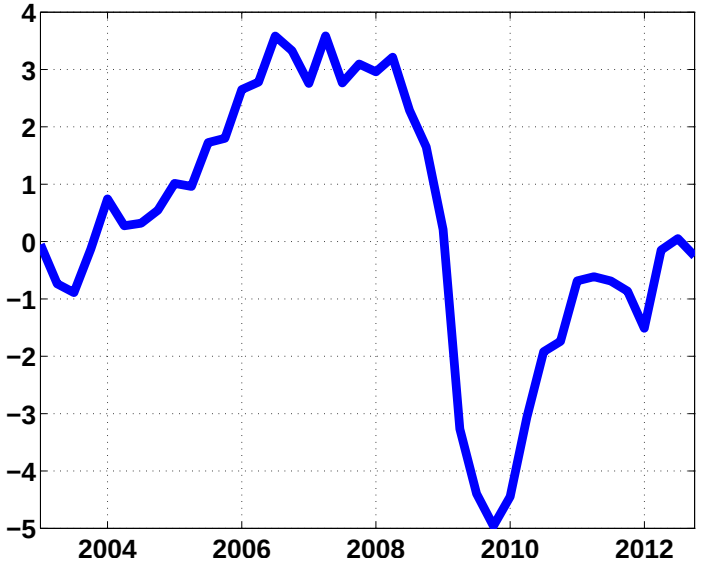
TFP with total hours



Labor productivity



Labor quality



TFP with total labor inputs

Summary of the facts

- Large decline in main aggregate variables.
- Households deleveraging process: private debt and housing price plunged.
- Total factor productivity dropped, but labor productivity and labor quality increased.

Objective of this project

- To explore the quantitative properties of environments where recessions are caused by worse financial conditions faced by households.

- These environments have

1. Real frictions that make difficult to switch from production of consumption goods to exports or investment.
2. Households differing in wealth and job market prospects.
3. A financial system used widely by households to buy houses which are inferior goods and not wanted by the super-rich.
4. Asset prices respond to market conditions.
5. Frictions in the goods market generate movements in measured TFP.

Ingredients of this project

- It is a small open Aiyagari/Krusell-Smith economy with a housing market and a stock market.
- Borrowing has to be collateralized by the value of housing. The financial terms available are the financial conditions and are subject to shocks.
- Like in Huo & Rios-Rull(13) there are goods market frictions that generate TFP losses, job market frictions, and adjustment costs to move into tradable production.

Findings

- A recession can be triggered by financial shocks to households.
- It shares most of the features of the Great Recession.
- Insufficient reductions in assets (housing and stocks) prices.
- For now!!

The Model

Households: Preferences

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

$$c_N = \left(\int_0^{\mathrm{I}_N} c_{Ni}^{\frac{1}{\rho}} \, di \right)^{\rho}$$

  - Under equal consumption of each variety: $c_N \, \mathrm{I}_N^{\rho} = \left[\int_0^{\mathrm{I}_N} c_{Ni}^{\frac{1}{\rho}} \, di \right]^{\rho}$
- Households have to search for varieties, its number is a *choice*.

$$\mathrm{I}_N = d \; \Psi^d(Q^g)$$

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

- Households also like tradables and housing and dislike goods searching

$$u\left[c_A(c_N \, \mathrm{I}_N^{\rho}, c_T), \; h, \; d\right]$$

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.

- **Tradables**.
  - Measure one of competitive firms.
  - (Large) Adjustment costs to both capital and labor.
  - Its output is used for exports, investment, and (part of) consumption.
  - $F^T(k, \ell)$ may have decreasing returns.
- **Nontradables**
  - Measure one of monopolistic firms each one producing a different variety.
  - Each firm/variety has a measure one of locations, each location has its own production function $F^N(k, \ell_1, \ell_2)$.
    - ⋆ ℓ_1 Committed to the location. (Sales staff)
    - ⋆ ℓ_2 Can be reallocated within the period. (Production Staff)
  - Locations may or may not be filled (get a customer). They produce only for consumption.
  - Firms post prices before the location is filled.

Goods markets

- Perfect competition and frictionless markets for tradables.
- Search frictions in the markets for nontradables:

- Households look for varieties.
- CRS matching function $M(D,1)$. Market tightness is $Q^g = \frac{1}{D}$.
- Random search. There is no possibility of attracting more customers with lower prices (we are working on a paper where there is shopping and searching simultaneously).
  - The probability that a shopper finds a firm-variety: $\Psi^d(Q^g) = \frac{M}{D}$
  - The probability that a firm finds a shopper is the measure of filled locations or of consumers buying the good: $\Psi^f(Q^g) = \frac{M}{1} = M(D,1)$.

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

$$\log w - \log \overline{w} = \varepsilon_w \left(\log Y - \log \overline{Y} \right)$$

It simplifies things.

Gornemann, Kuester, and Nakajima (2012).

Assets markets: Financial assets and houses

- Total housing $\overline{\mathrm{H}}$ 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

$$V(S,\epsilon,e,a) = \max_{c_{N,i},c_T,\mathrm{I}_N,h,d} u(c_A,h,d) + \beta \sum_{\epsilon',e',\theta'} \Pi^{\theta}_{\theta,\theta'} \Pi^{w}_{e'|e,\epsilon}(S') \Pi^{\varepsilon}_{\epsilon,\epsilon'} \; V[S',\epsilon',e',a'(S',b,h)]$$

subject to

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

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

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

$$\mathrm{I}_N = d\;\Psi^d[Q^g(S)] \qquad \text{SC}$$

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

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 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

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

- 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

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

subject to

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

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

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

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

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

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

$$\begin{aligned} k' &= (1-\delta_k)k + i - \phi^{T,k}(k,i) \\ \ell &= n\overline{\epsilon}(S) \\ n' &= [1-\overline{\delta}_n(S)]n + v \\ S' &= G(S). \end{aligned}$$

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

$$D(S) = \int d(S, x)\, dx,$$

- Nontradable prices satisfies

$$p(S) = p_i(S, K_N, N_N)\, dx,$$

- Housing market clears

$$\int h(S, x)\, dx = \mathrm{H}.$$

Equilibrium

- Average separation probability and labor force quality

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

- 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

$$\log w(S) - \log \overline{w} = \varepsilon_w \left(\log Y(S) - \log \overline{Y} \right)$$

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

Mapping the Model to Data

Functional forms

- Preferences

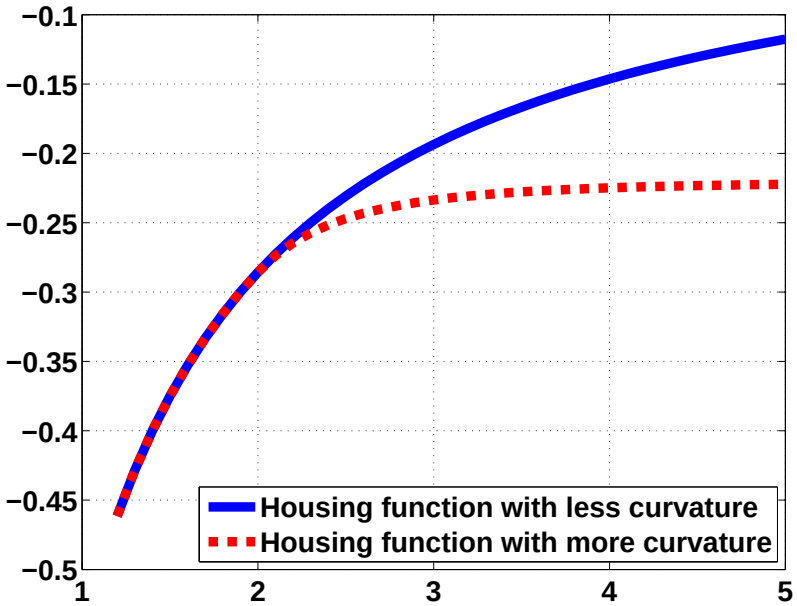
$$u(c_A, h, d) = \frac{1}{1-\sigma_c}\left(c_A - \xi_d \frac{d^{1+\gamma}}{1+\gamma}\right)^{1-\sigma_c} + v(h)$$

- where there is an Armington aggregator for consumption

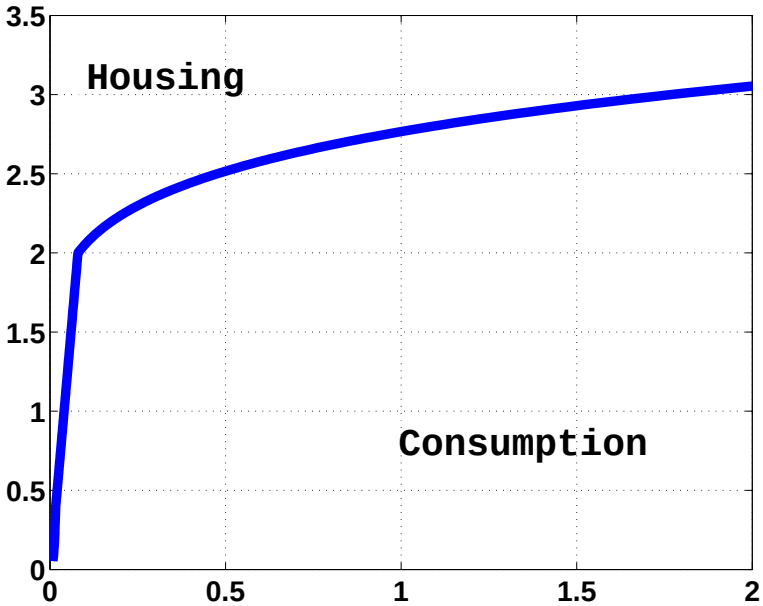
$$c_A = \left[\omega\left(c_N \mathrm{I}_N^{\rho}\right)^{\frac{\eta-1}{\eta}} + (1-\omega) c_T^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

- and houses are inferior goods.

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



Housing utility function



Policy function: consumption vs housing

Functional forms

- Production function

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

- 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

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

- 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_c^1	2.0
Risk aversion for housing, σ_c^2	10.0
Curvature of shopping, γ	2.0
Elasticity of substitution bw tradables and nontradables, η	0.80
Cutoff value for housing utility, $\widehat{h}$	2.0
Price markup, ρ	1.1
Loan to value ratio, λ	0.85
Interest rate for international bonds, r^*	4%

Endogenously determined parameters: aggregate

Target	Value	Parameter	Value
Wealth to output ratio	4.70	β	0.985
Housing value to output ratio	1.67	ξ_h	0.61
Debt to output ratio	0.75	ϵ_4	12.51
Share of tradables	0.30	ω	0.95
Occupancy Rate	0.81	ν	0.81
Capital to output ratio	2.75	δ_k	0.006
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	$\overline{w}$	0.07
Units Parameters			
Output	1	z_N	0.85
Relative price of nontradables	1	z_T	0.44
Market tightness in goods markets	1	ξ_d	0.03

Endogenously determined parameters: cross-section

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	0.047
Wealth Gini index	0.82	$\Pi_{1,4}^{\epsilon}$	0.0003
Earning Gini index	0.64	$\Pi_{4,1}^{\epsilon}$	0.0031
Earning autocorrelation	0.95	$\Pi_{1,1}^{\epsilon}$	0.9894
Earning stdev	0.12	$\Pi_{2,2}^{\epsilon}$	0.9860

Transition matrix	ϵ_1	ϵ_2	ϵ_3	ϵ_4
ϵ_1	0.9894	0.0101	0.0000	0.0003
ϵ_2	0.0067	0.9860	0.0067	0.0003
ϵ_3	0.0000	0.0101	0.9894	0.0003
ϵ_4	0.0031	0.0031	0.0031	0.9904
Skill Value	0.2259	0.4496	0.8948	12.50

Dynamic parameters

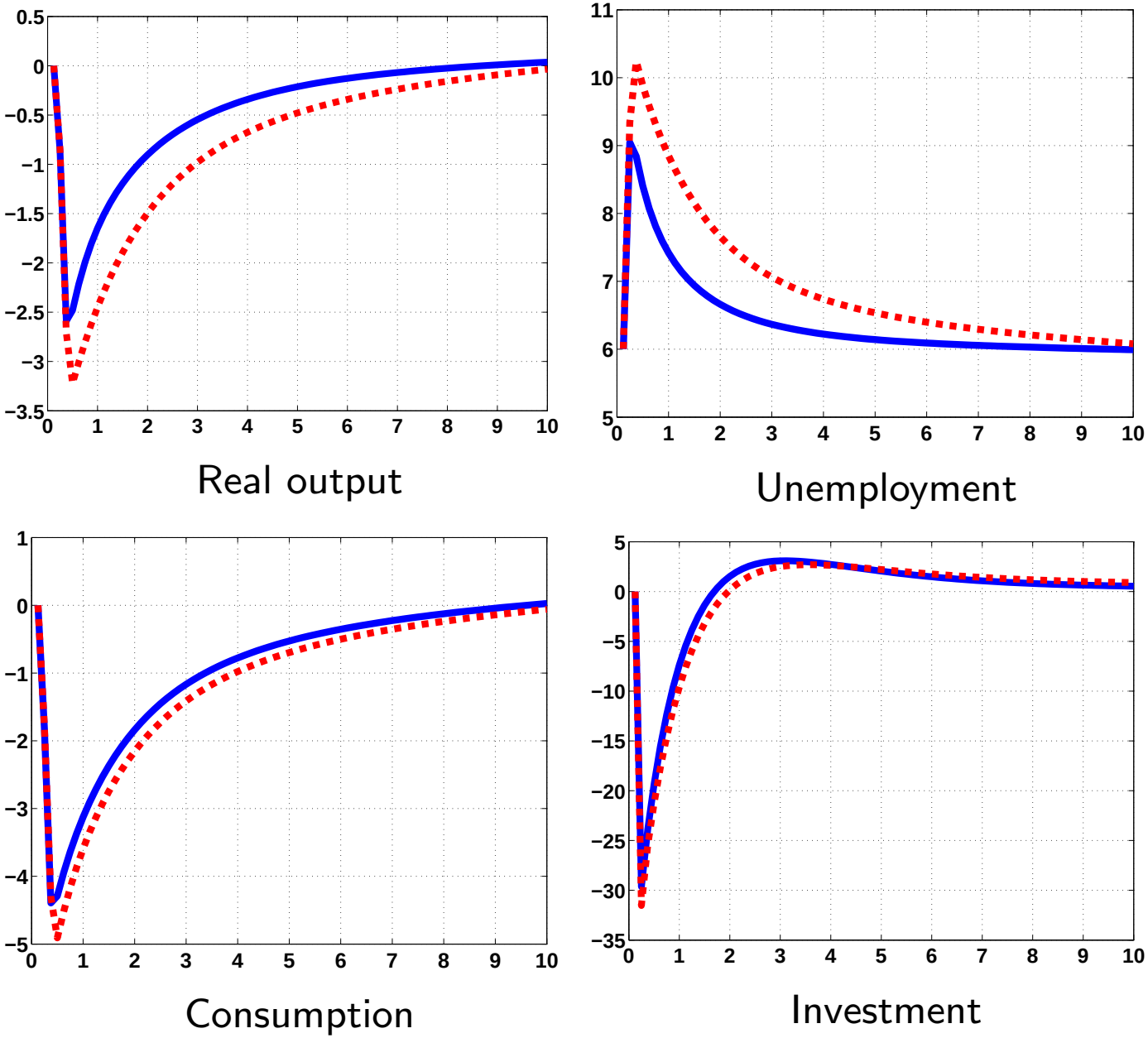
Target	Value	Parameter	Value
Decrease of investment	35%	ε^N	1.25
Increase of tradable output	1.5%	$\varepsilon^{T,n}$	2.80
Symmetry of tradable adjustment costs	$\varepsilon^{T,k} = \varepsilon^{T,n}$	$\varepsilon^{T,k}$	2.80
Decrease of TFP	1%	μ	0.50
Wage elasticity w.r.t. output	0.45	ε_w	0.45

Experiments: Financial Shocks

Experiments

1. Decrease the loan to value ratio from 0.85 to 0.75 in period 1, with flexible and fixed wage.
2. Decrease the loan to value ratio from 0.85 to 0.75 gradually in 4 years, with flexible and fixed wage.
3. Increase the interest rate for borrowing from 4% to 4.3% in period 1, with flexible and fixed wage.
4. increase the interest rate for borrowing from 4% to 4.3% gradually in 4 years, with flexible and fixed wage.
5. increase both the loan to value ratio from 0.85 to 0.75, and the interest rate for borrowing from 4% to 4.3% gradually in 4 years, with flexible wage.

1: Sudden change of λ. Flex. w Fixed w



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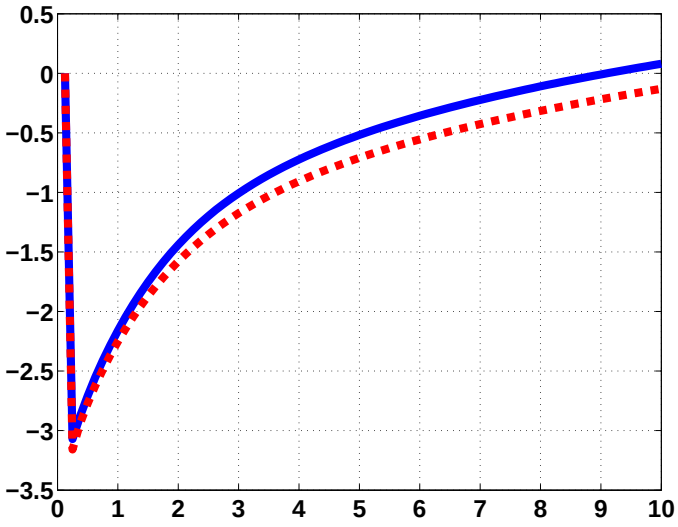
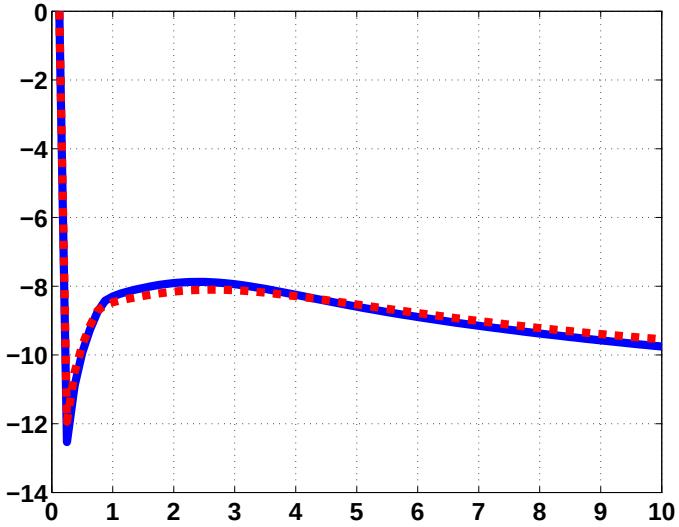
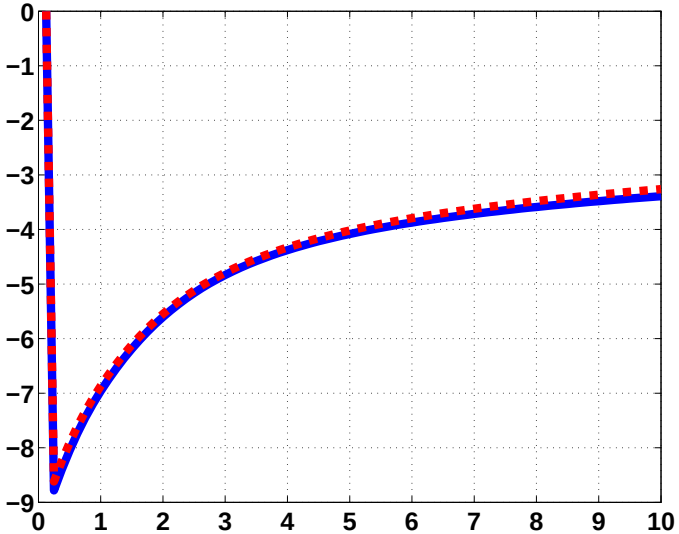


Wealth

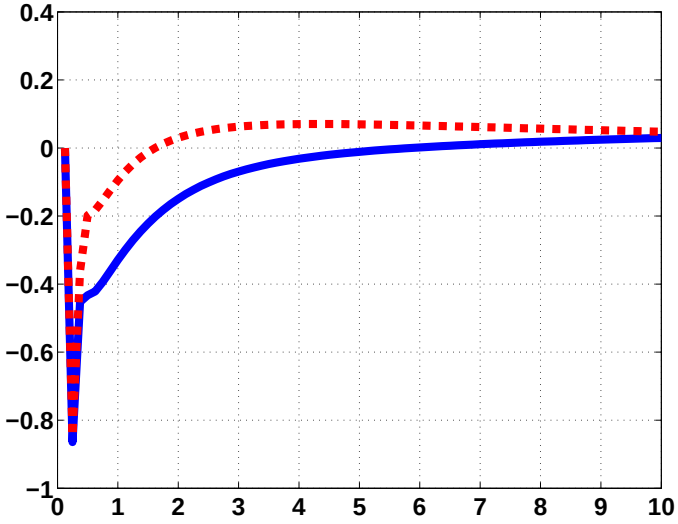


Debt

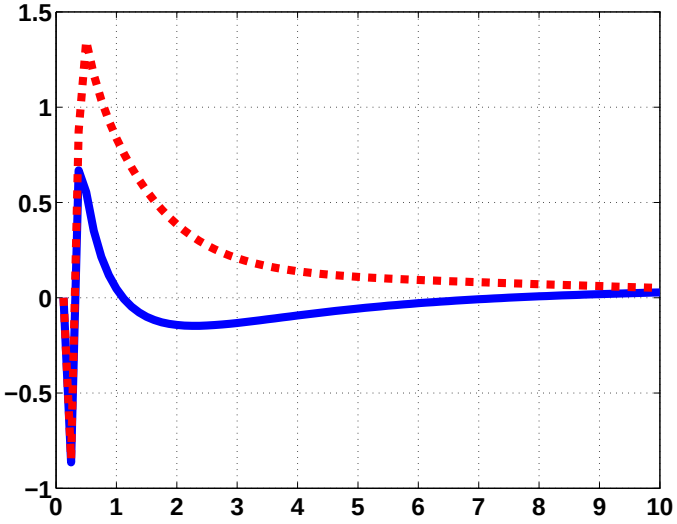


Housing price

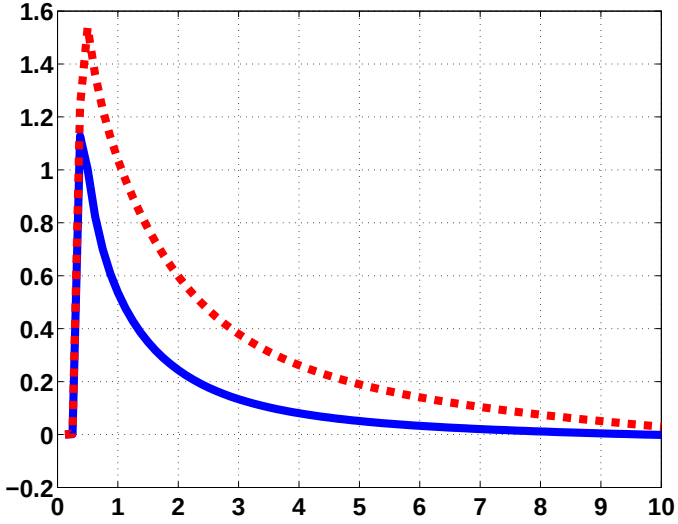
1. Sudden change of λ, Flex. w Fixed w



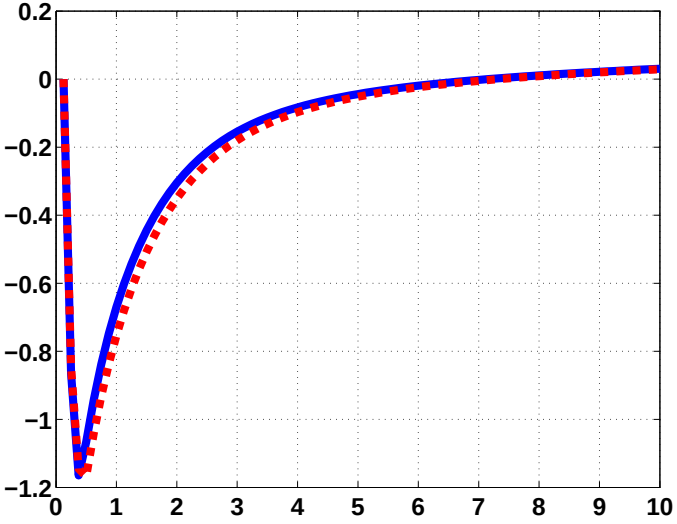
TFP with total hours



Labor Productivity

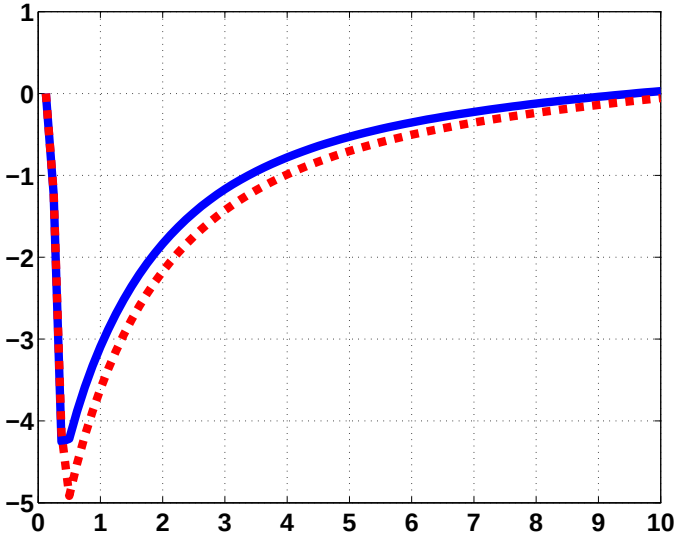


Labor quality

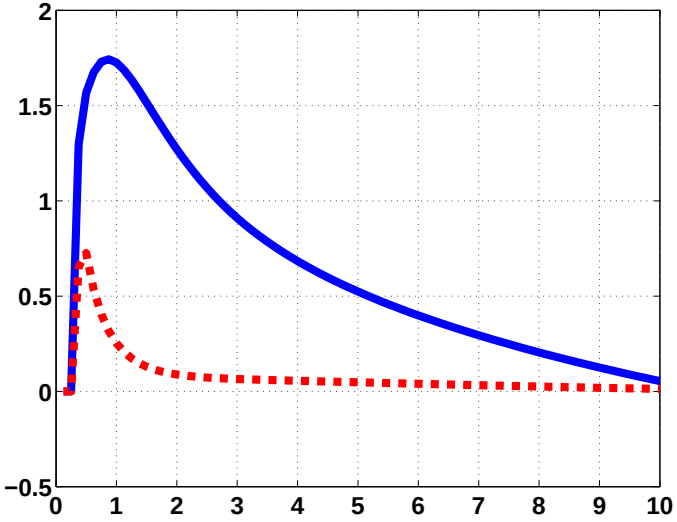


TFP with total labor inputs

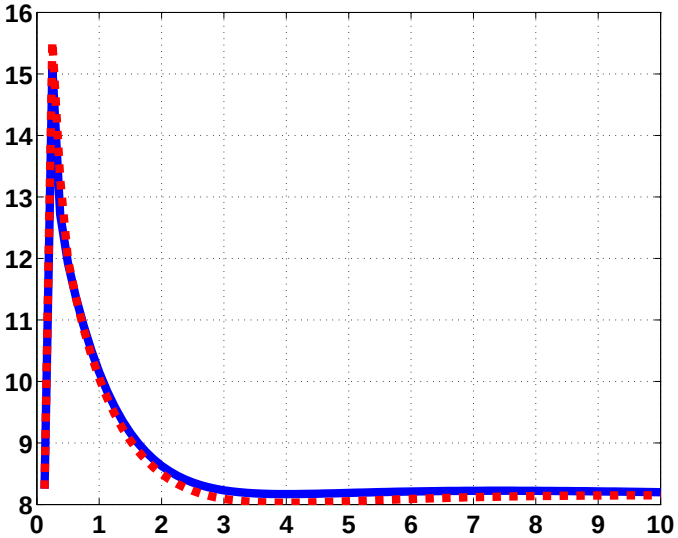
1. Sudden change of λ, Flex. w Fixed w



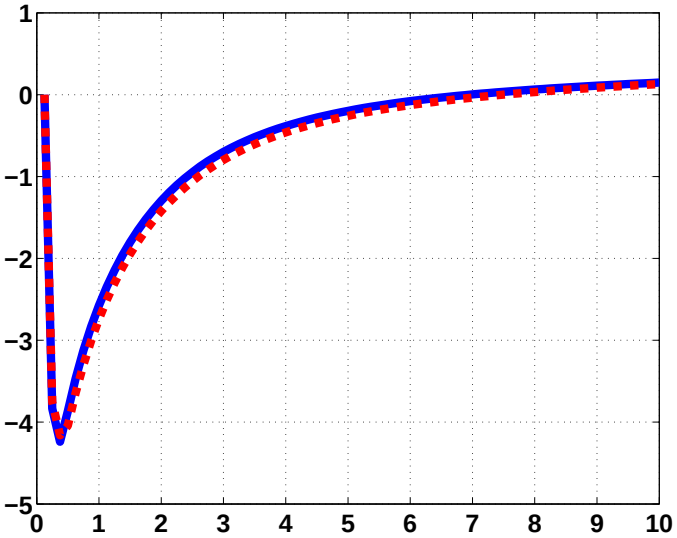
Nontradable sector



Tradable sector

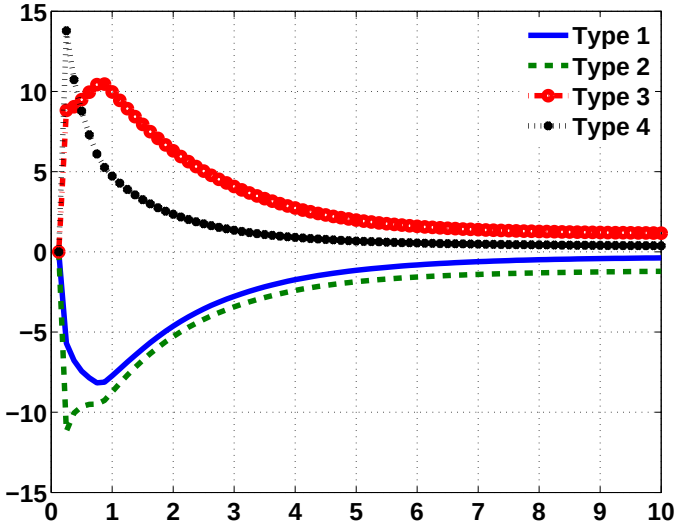


Net export/output ratio

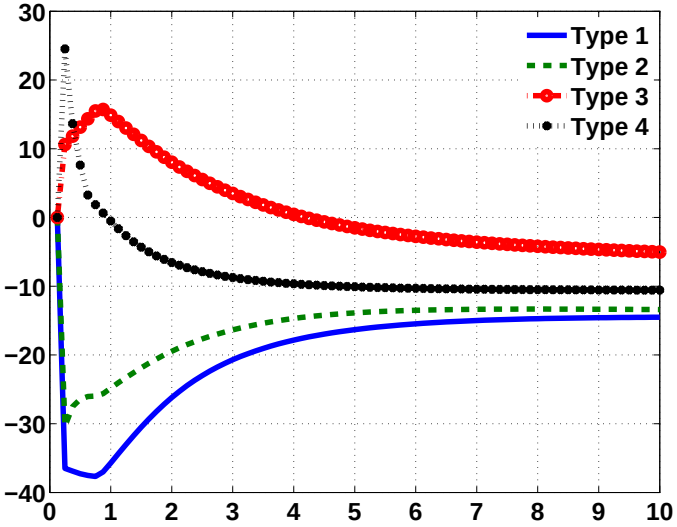


Aggregate search

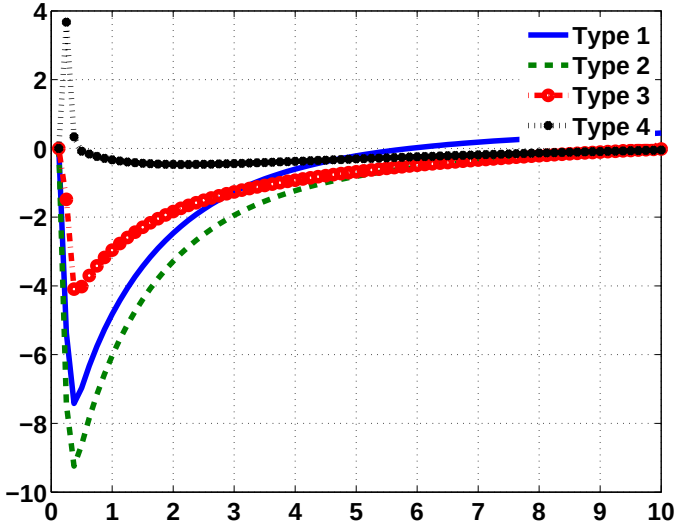
1. Fate of the different types, flexible wage



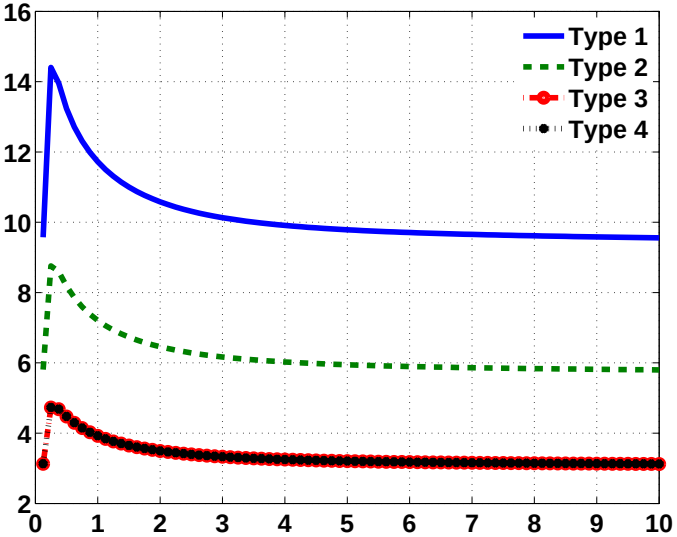
Housing



Debt

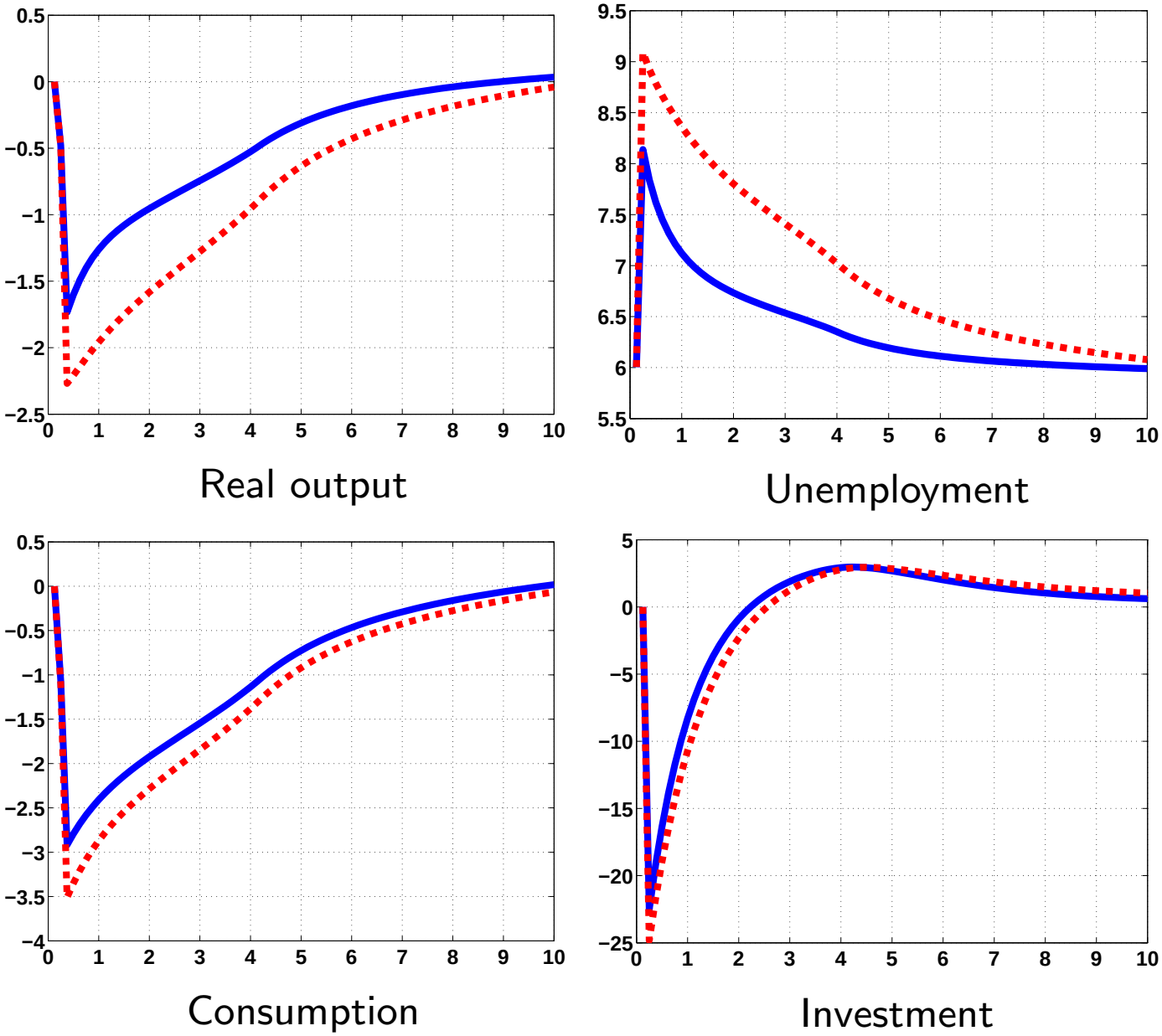


Consumption

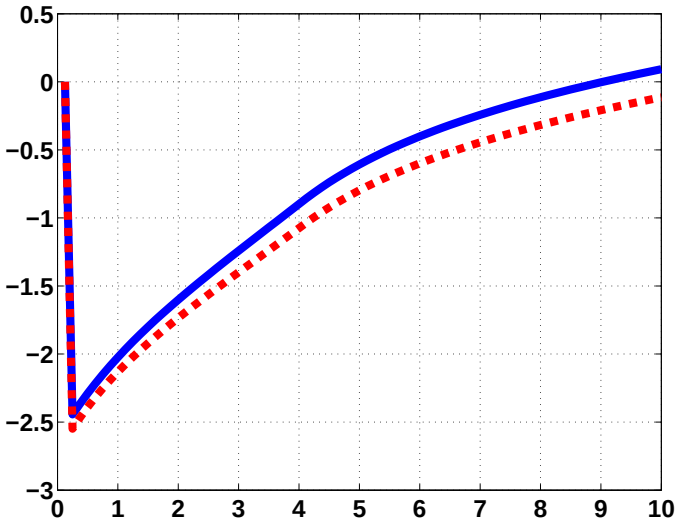


Unemployment rate

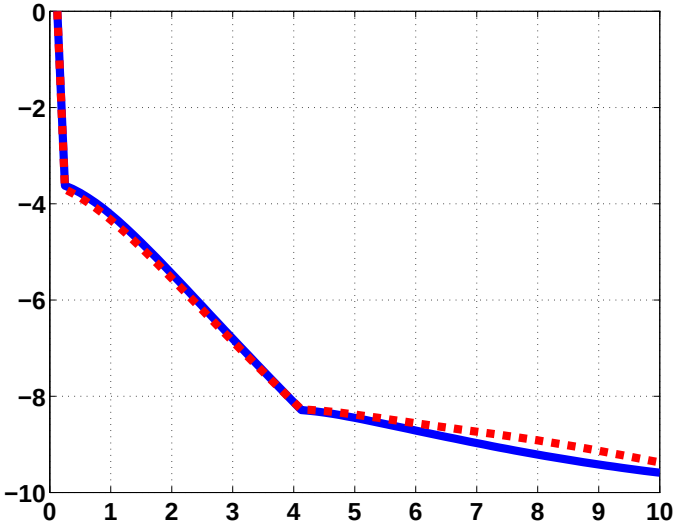
2, slow change of λ —— Flex. w - - - Fixed w



2, slow change of λ —— Flex. w - - - Fixed w



Wealth



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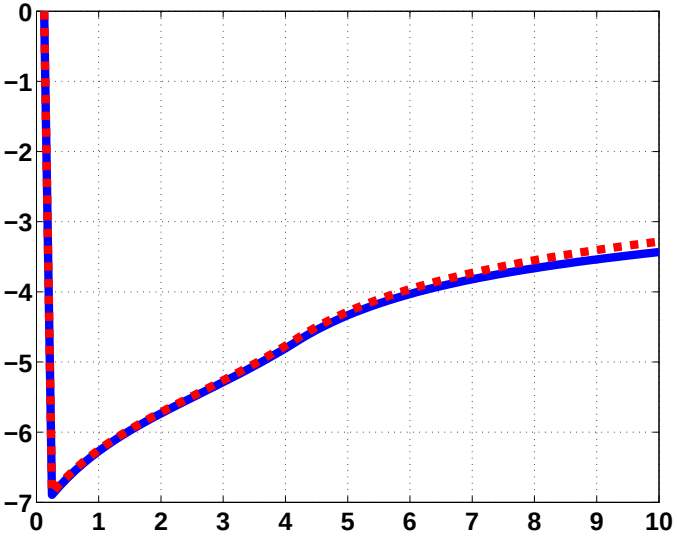
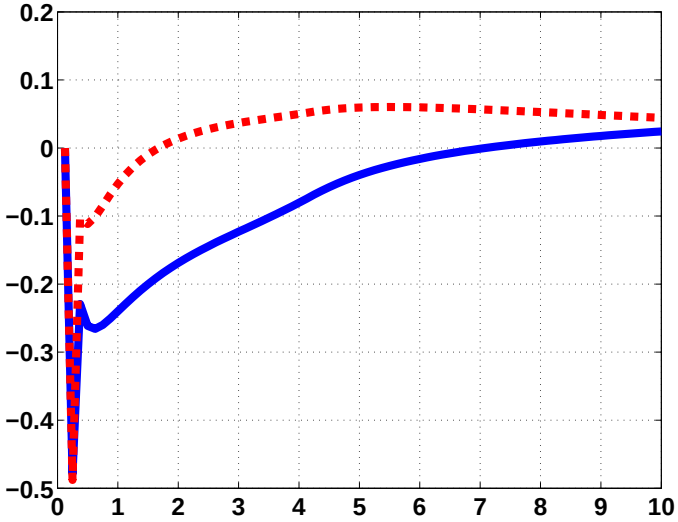
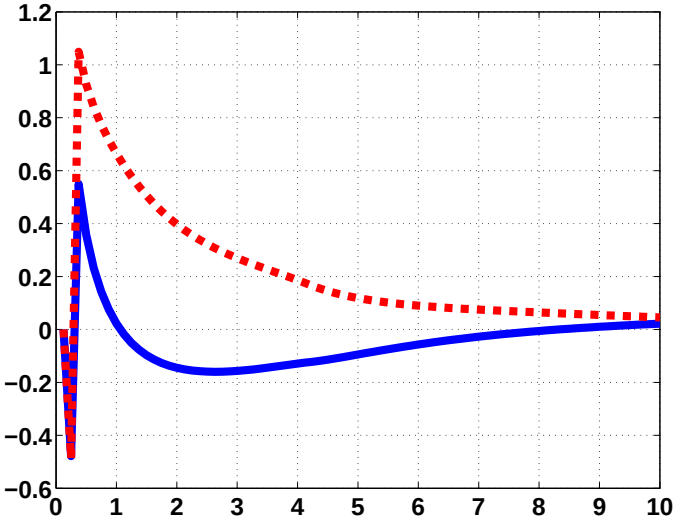


Housing price

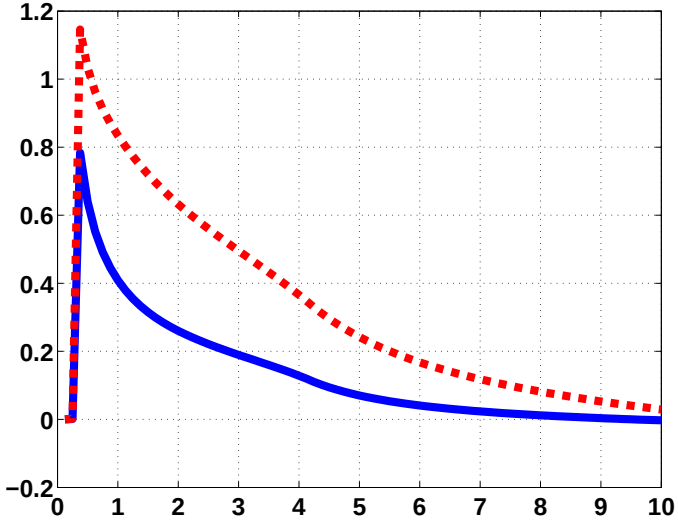
2, slow change of λ — Flex. w - - - Fixed w



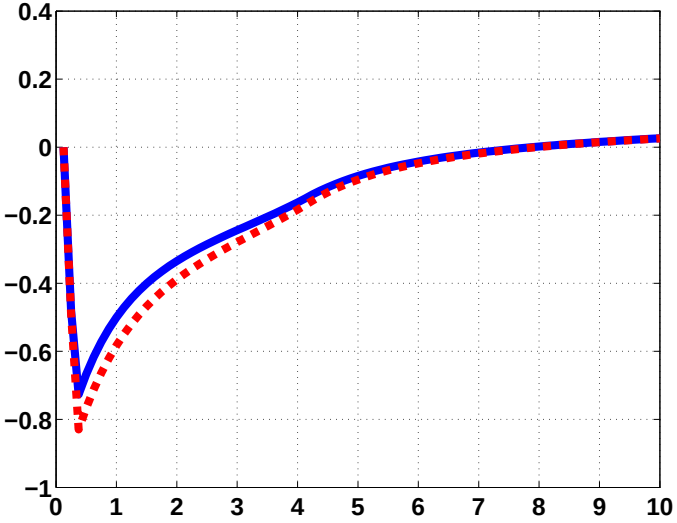
TFP with total hours



Labor Productivity

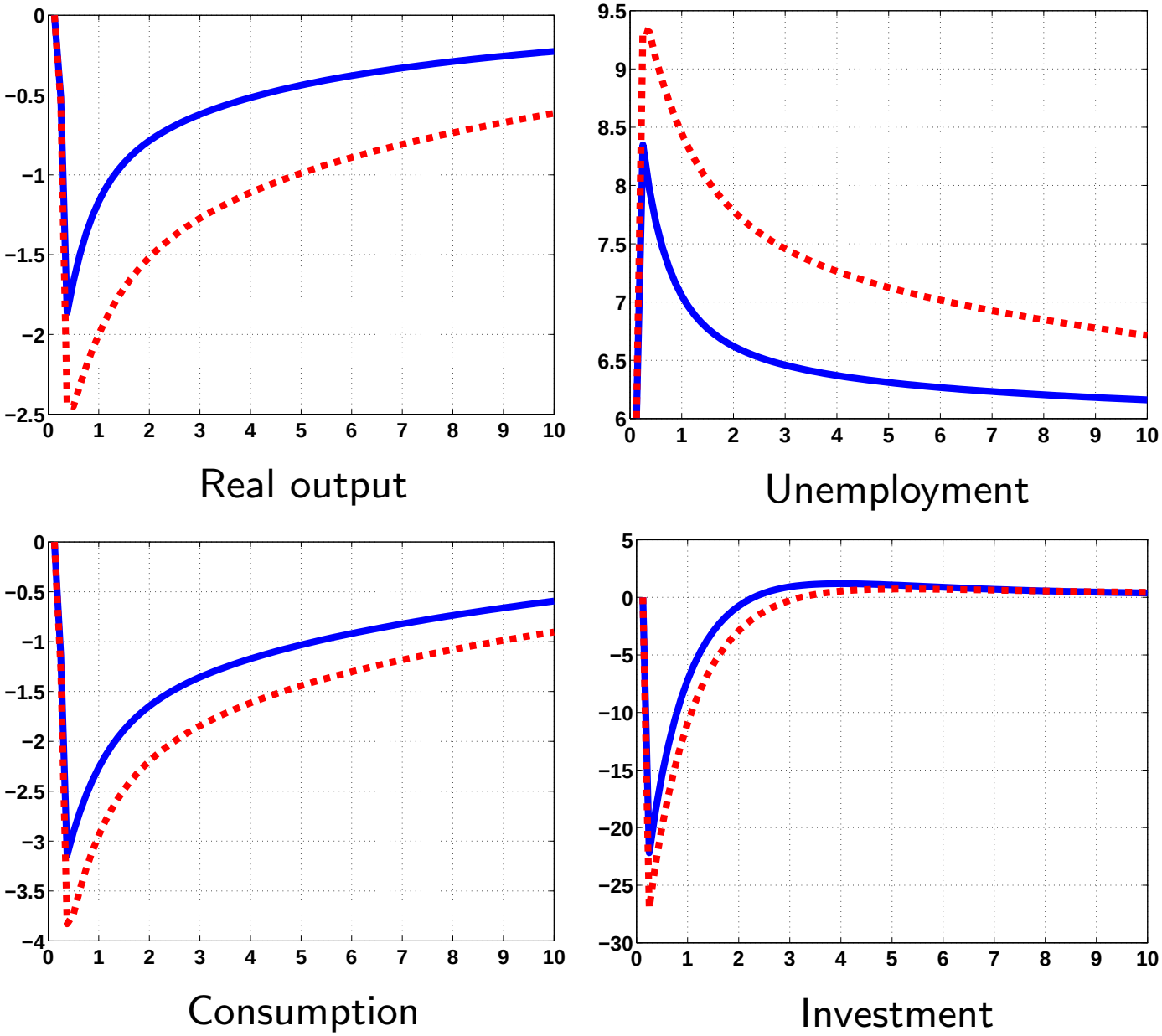


Labor quality

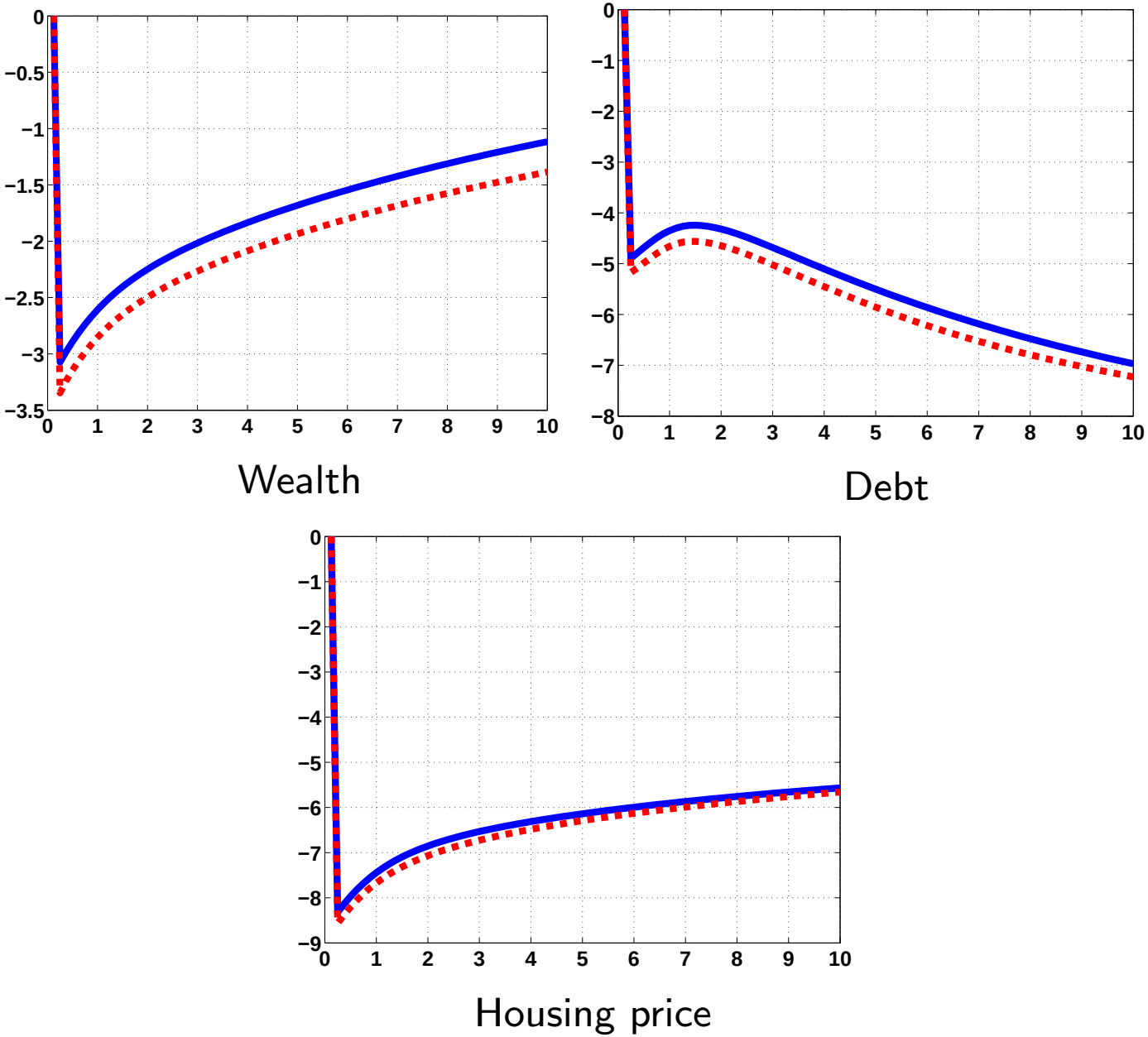


TFP with total labor inputs

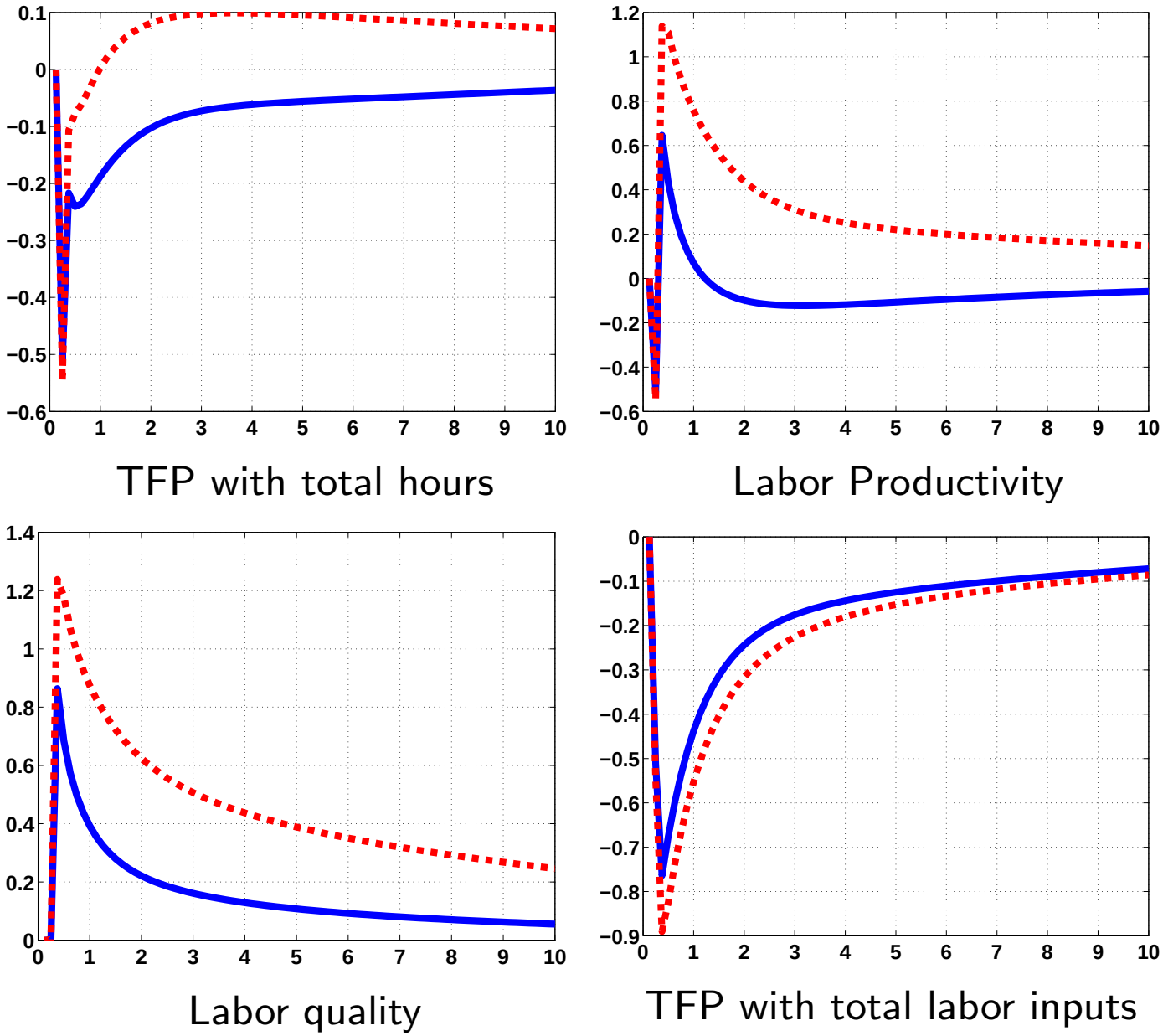
3. Sudden $\Delta\varsigma$, Flex. w Fixed w



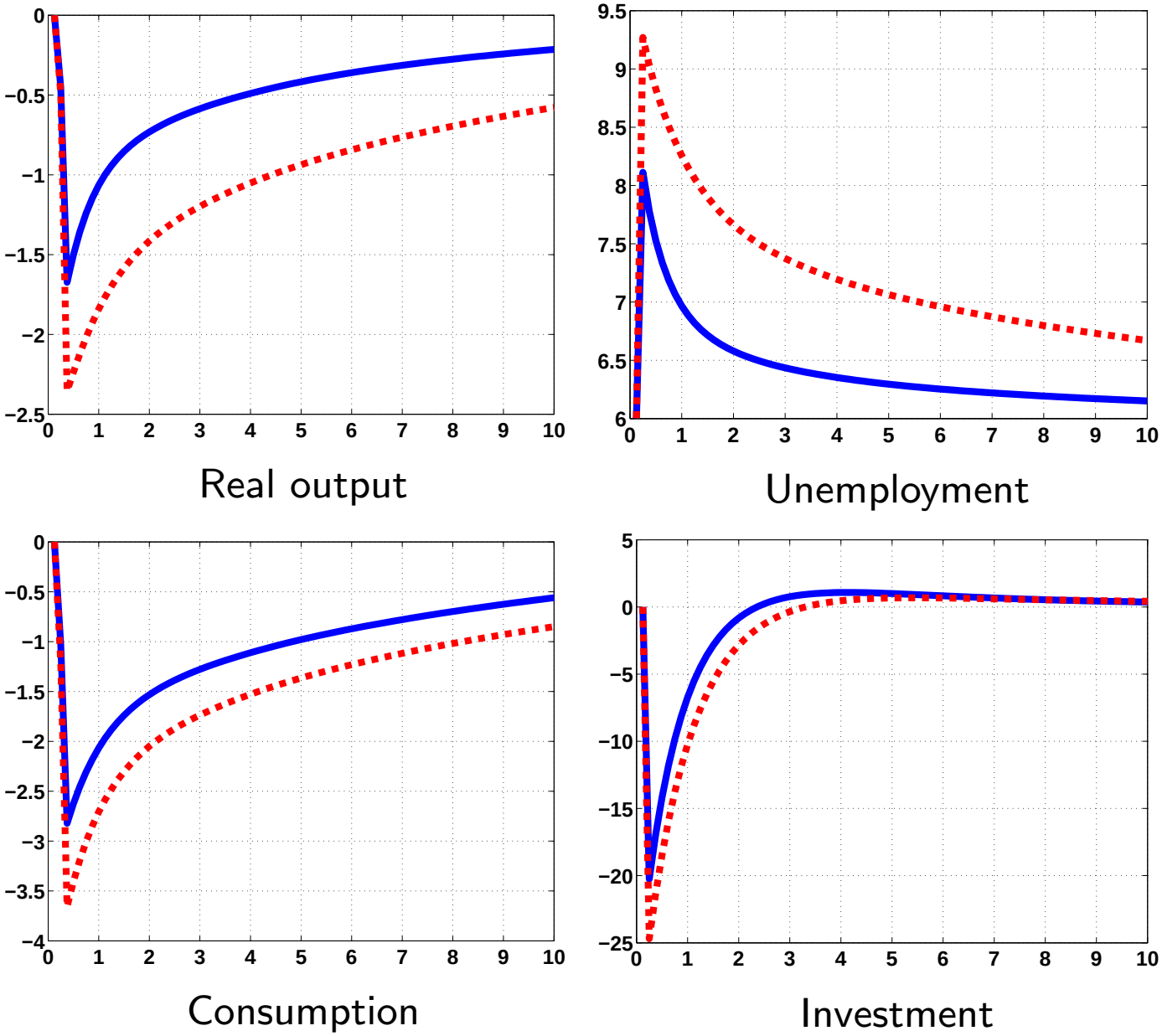
3. Sudden $\Delta\varsigma$, Flex. w Fixed w



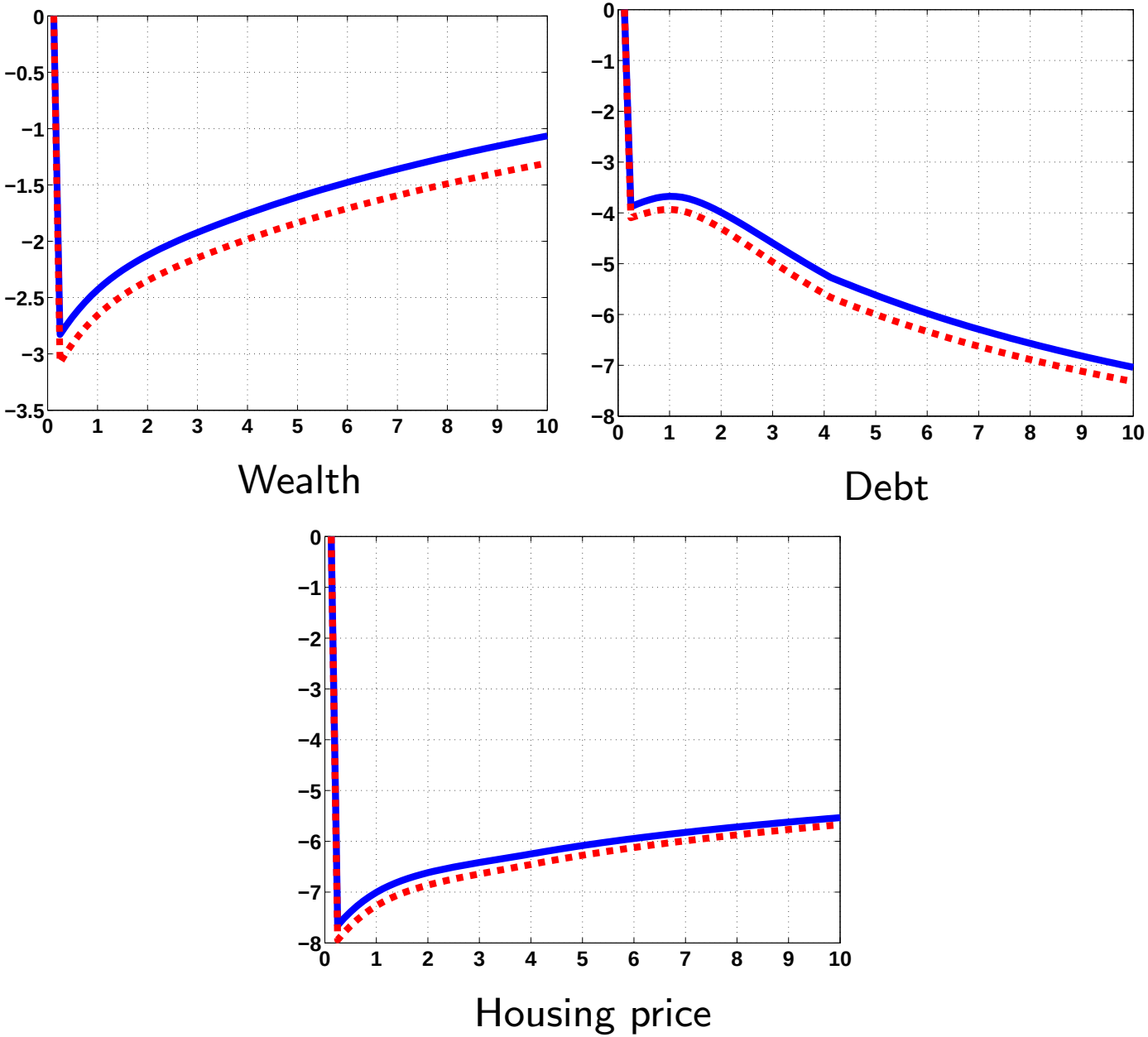
3. Sudden $\Delta\varsigma$, Flex. w Fixed w



4, Slow Δ_ς , Flex. w Fixed w



4, slow Δ_ς , Flex. w Fixed w



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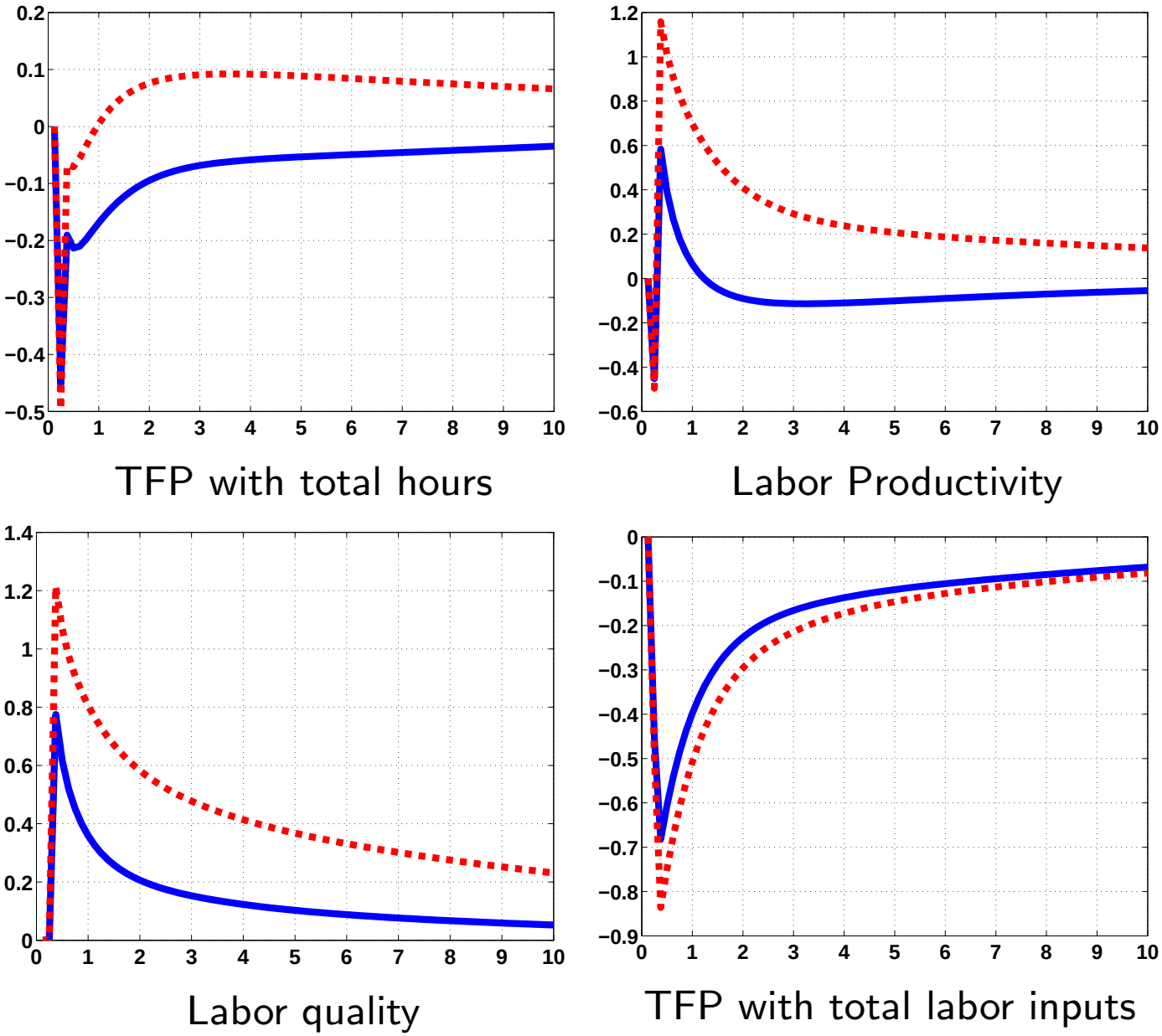
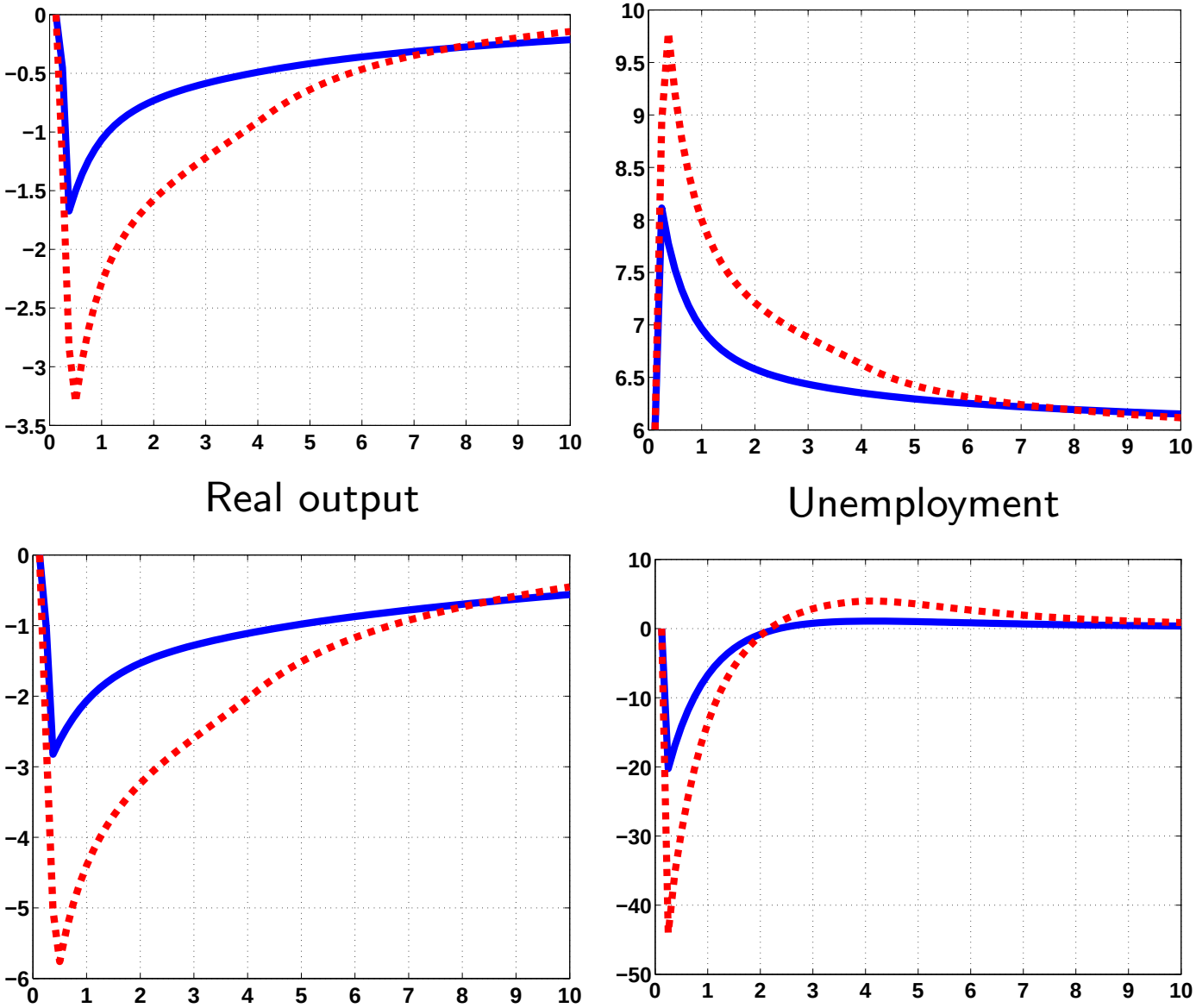
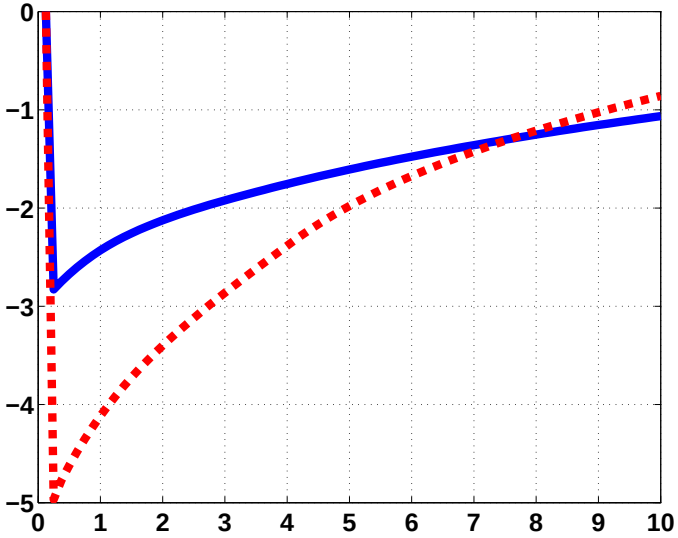


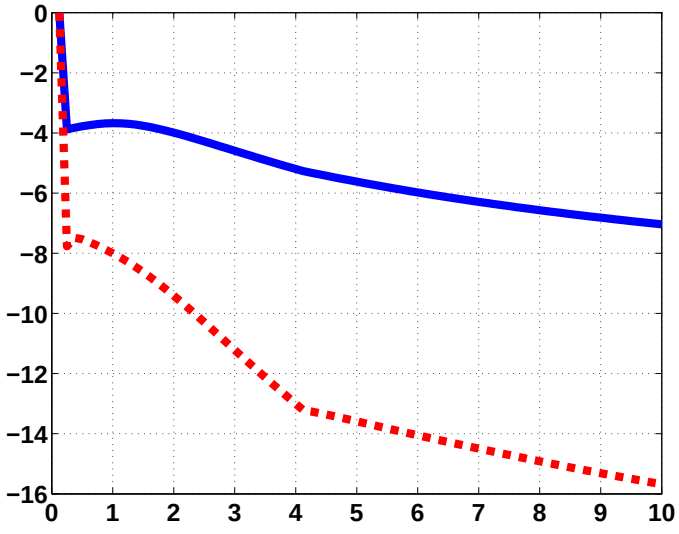
5, slow change of λ and $\Delta\varsigma$, Flex. w Fixed w



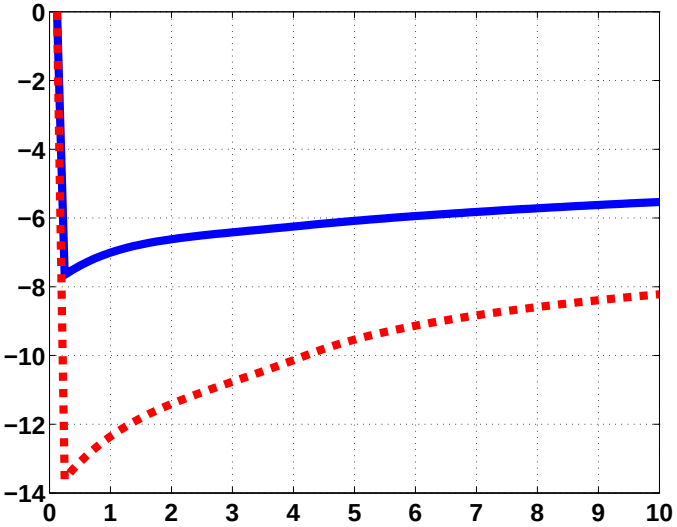
5, slow change of λ and $\Delta\varsigma$, Flex. w Fixed w



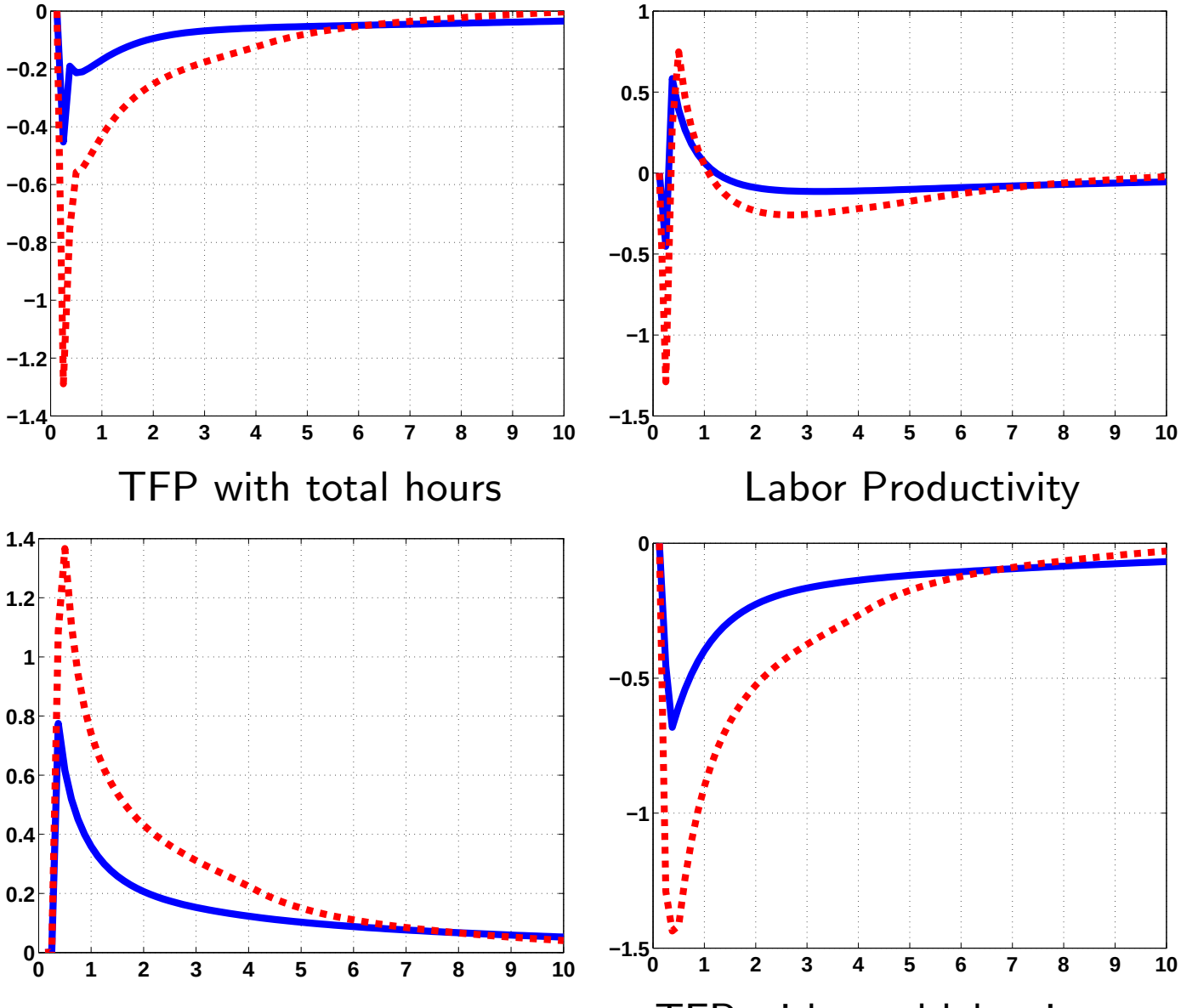
Wealth



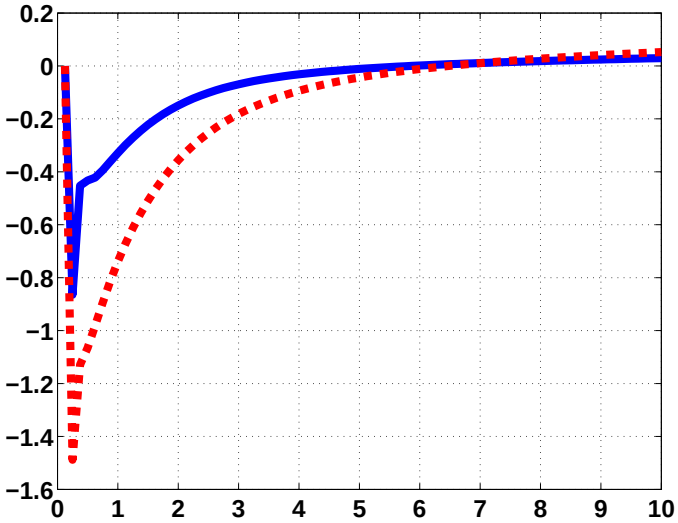
Debt



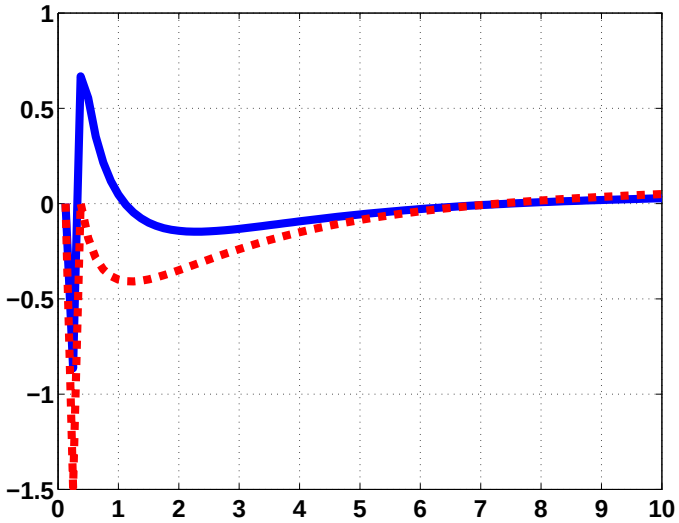
5, slow change of λ and $\Delta\varsigma$, Flex. w Fixed w



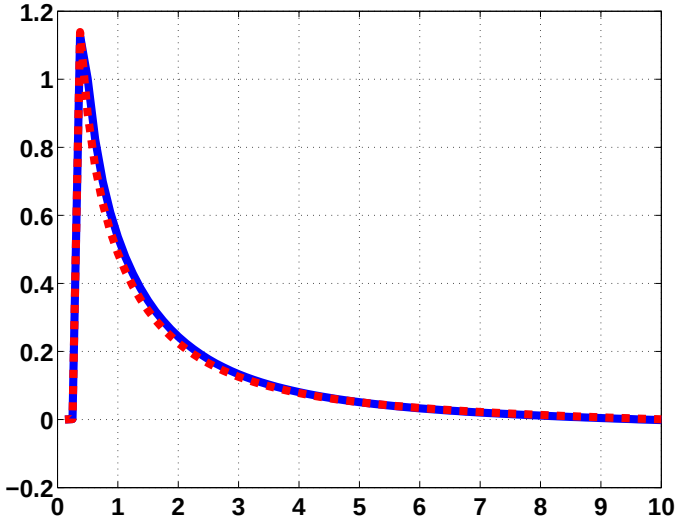
Results: larger TFP drop? Sudden change of λ with $\mu = 0.8$



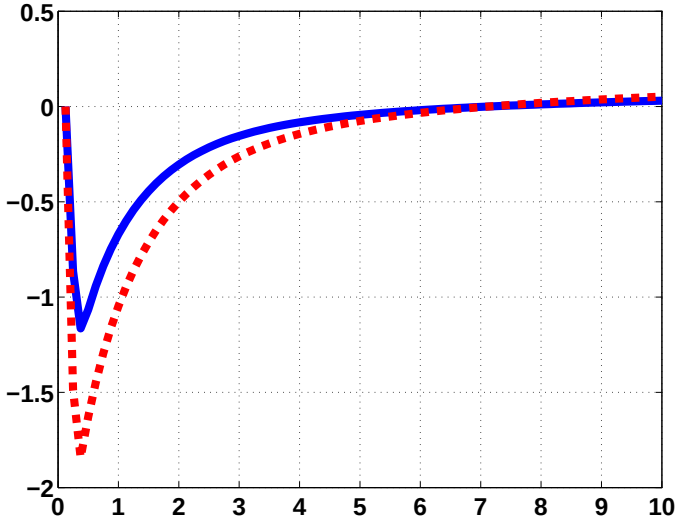
TFP with total hours



Labor Productivity



Labor quality

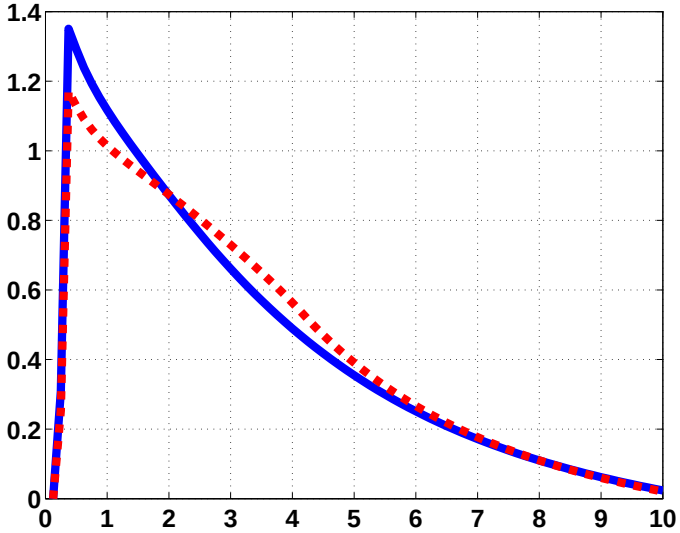


TFP with total labor inputs

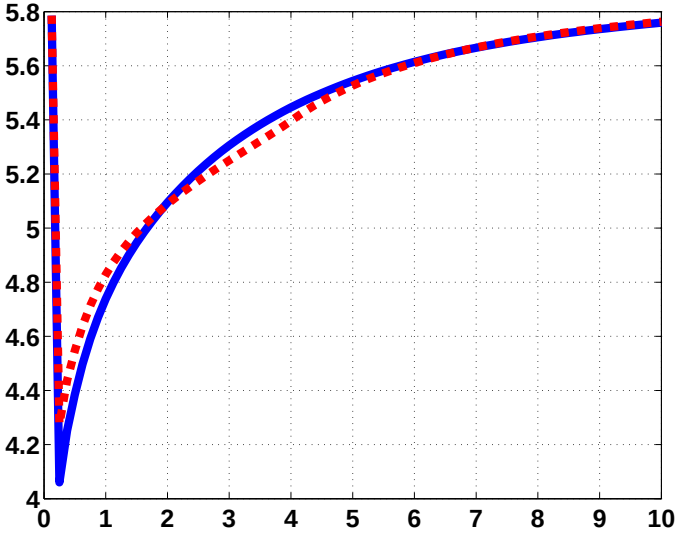
Model properties

- All the experiments generate
  - Drop of output, employment, investment and consumption.
  - Drop of wealth, housing price and debt.
  - Drop of total productivity, increase of labor quality and labor productivity.
- With fixed wage, the recovery of employment is much slower.
- With slow change of the financial condition, the initial drop of debt is smaller, which is the case in the data.
- A decrease of the loan to value ratio λ and an increase of borrowing cost have similar effects.

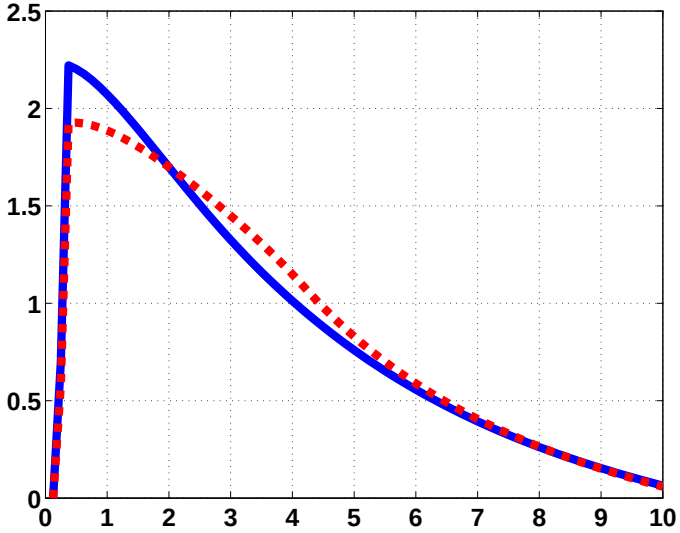
Results: an expansion? Change λ from 0.75 to 0.85



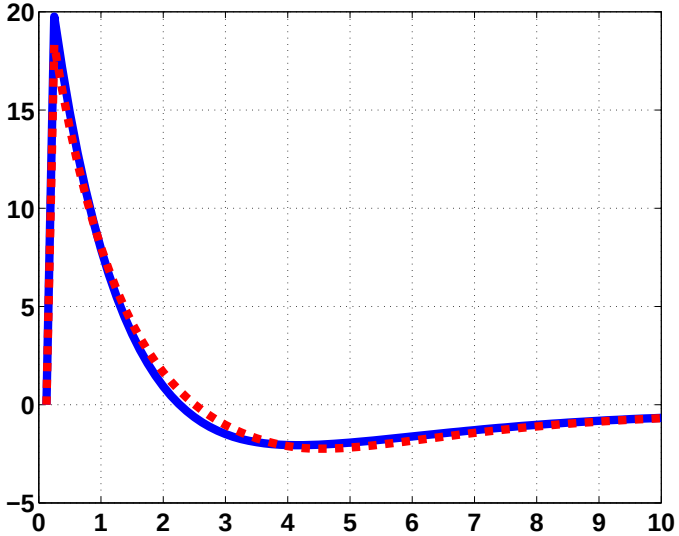
Real output



Unemployment

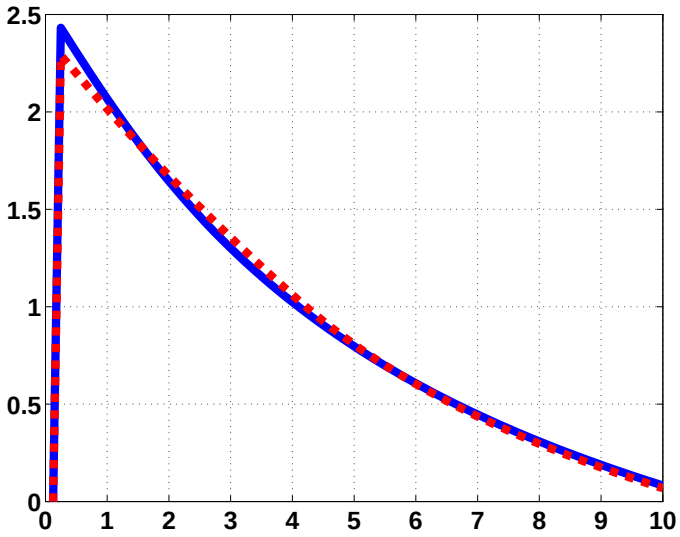


Consumption

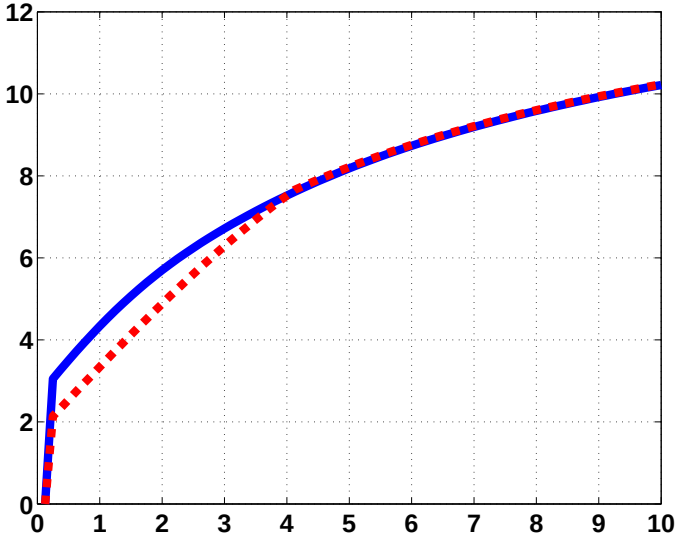


Investment

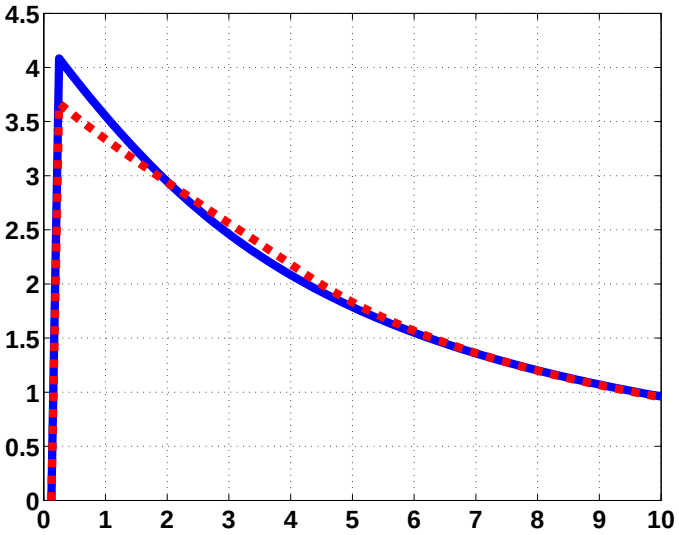
Results: an expansion? Change λ from 0.75 to 0.85



Wealth

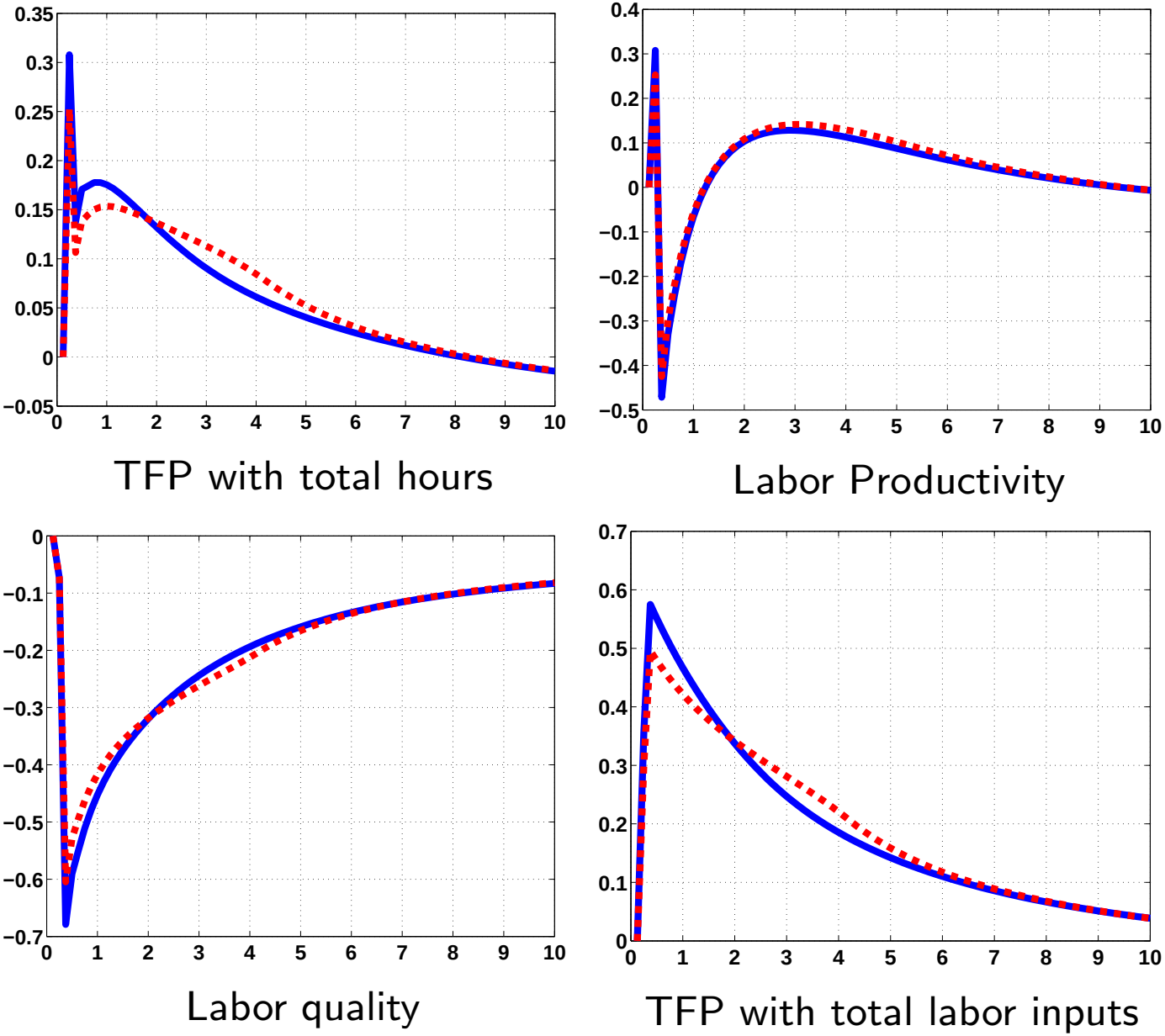


Debt

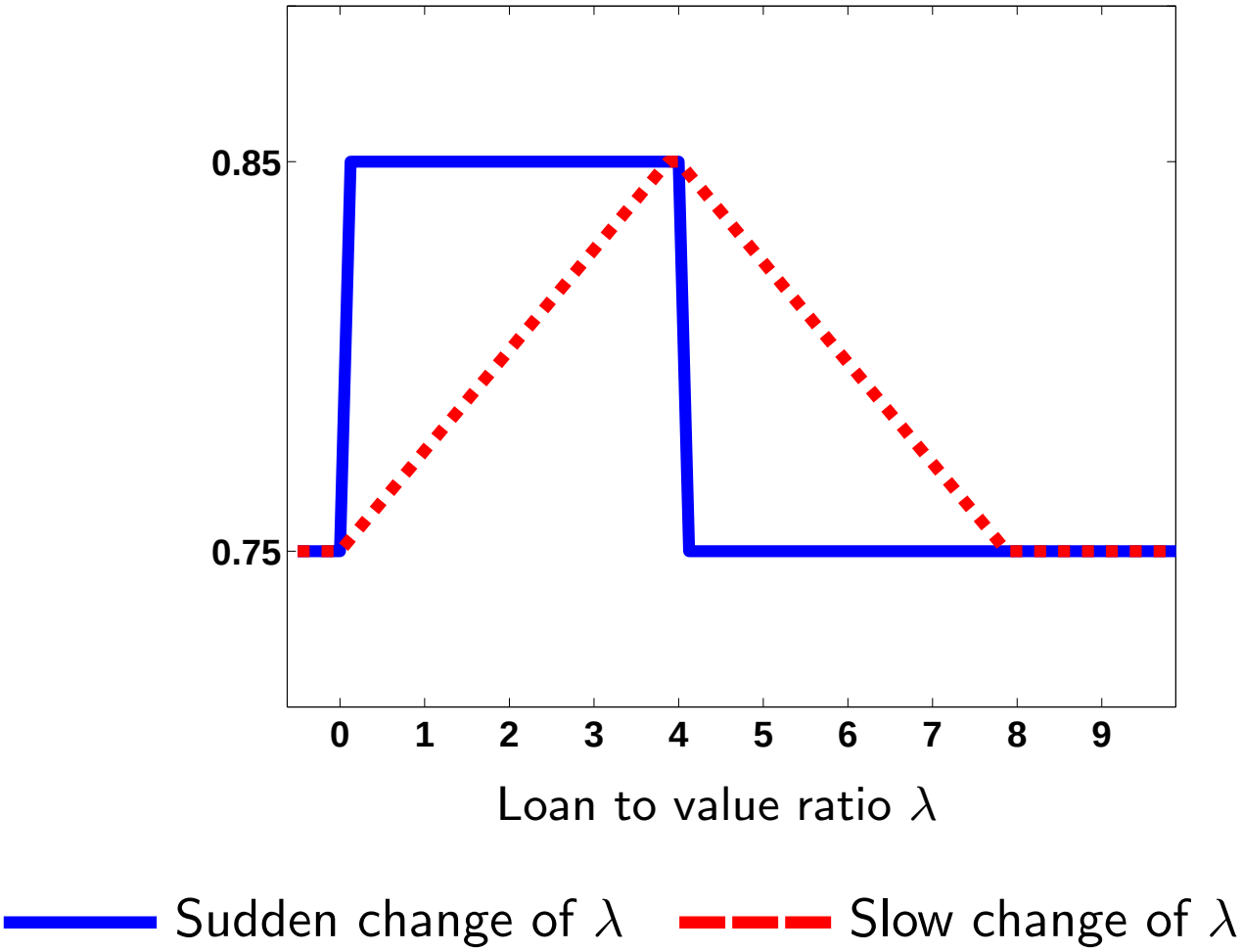


Housing price

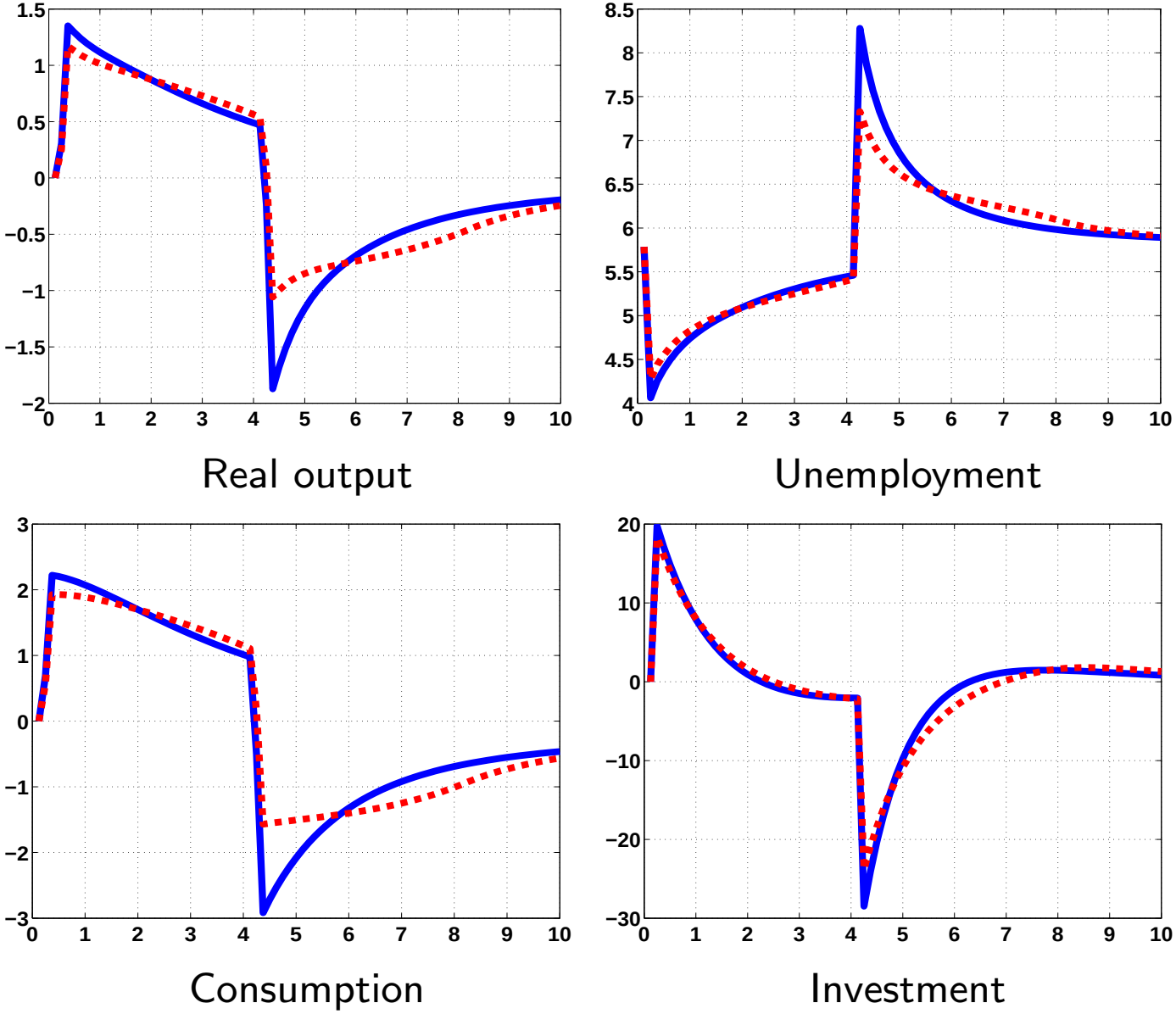
Results: an expansion? Change λ from 0.75 to 0.85



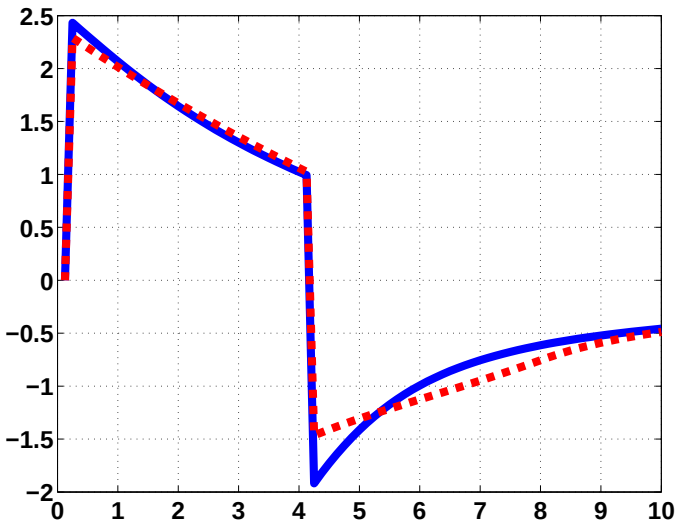
Results: a boom and bust cycle



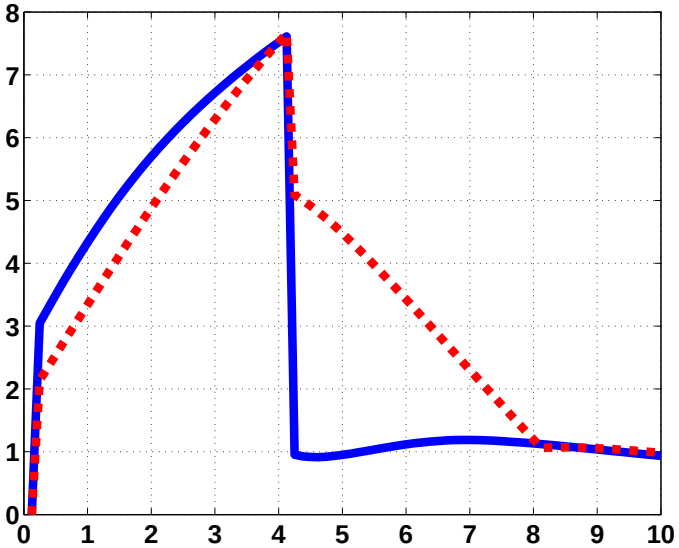
Results: a boom and bust cycle



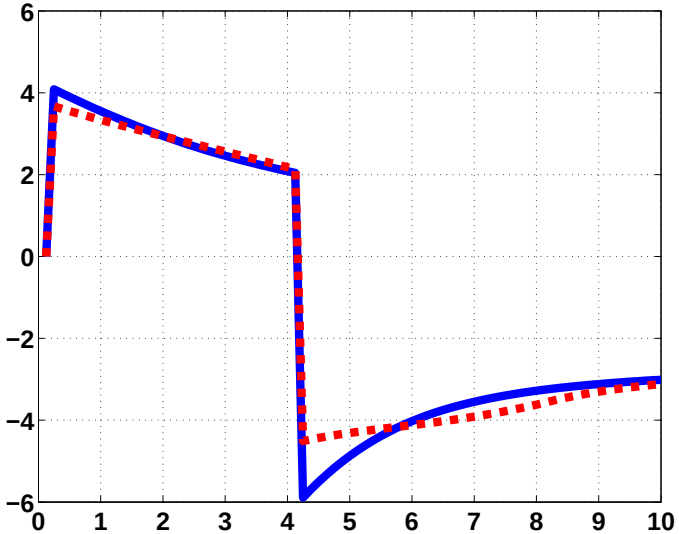
Results: a boom and bust cycle



Wealth

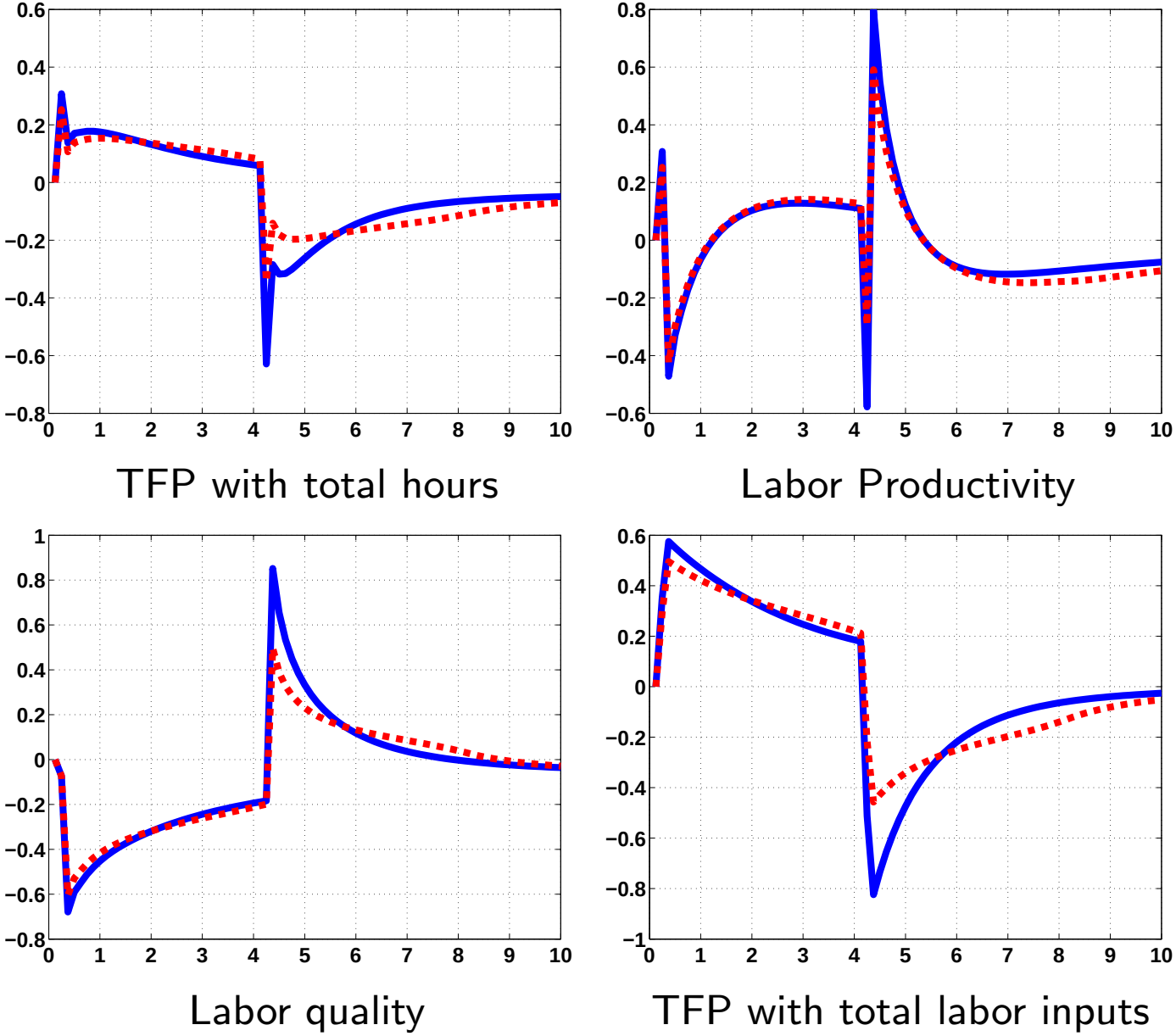


Debt



Housing price

Results: a boom and bust cycle



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- With fixed wage, the initial drop of employment is larger and the recovery is much slower.
- With slow change of the financial condition, the initial drop of debt is smaller, which is the case in the data.
- A decrease of the loan to value ratio λ and an increase of borrowing cost have similar effects.

Insufficient drop of housing price

- In the data: housing price $\downarrow$ 20%, housing value $\downarrow$ 36%.
- In the model: housing price $\downarrow$ 6% to 14%.

Problem:

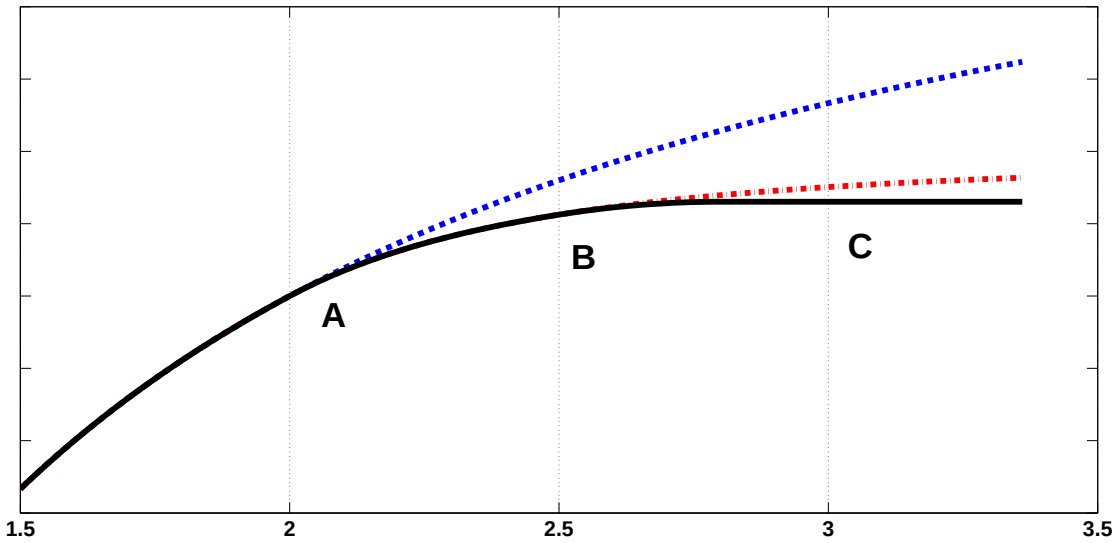
- Rich households with deep pockets pick up the slack. Not so much in the real world.
- Large decline of housing price may force poor households default their debt. Not allowed in the model.

Solution:

- Housing utility function with more curvature.
- Smaller initial load to value ratio λ gives larger room for drop of housing price without default.

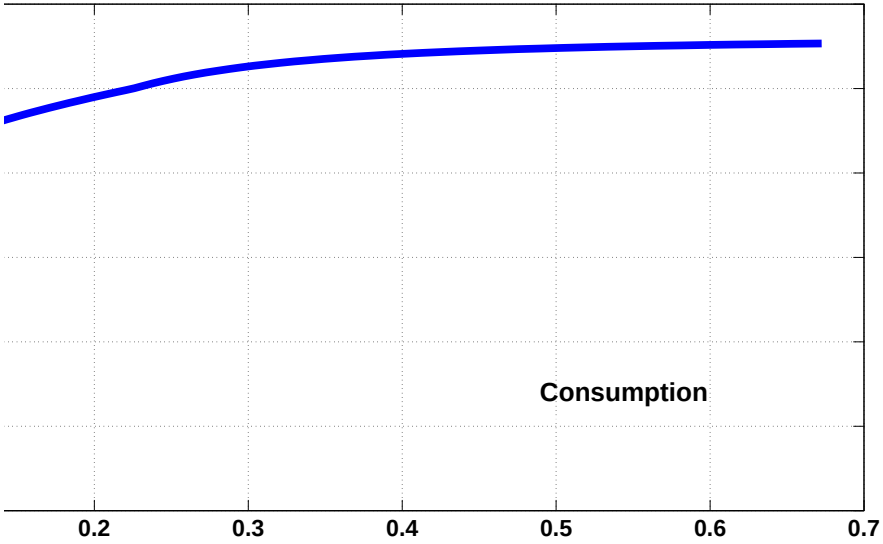
Housing utility function

A three-piece housing utility function.



- A: greater curvature to prevent rich households from expanding houses.
- B: greater curvature to prevent super rich households from expanding houses.
- C: upper bound for housing holding.

Housing as a function of consumption.



- Rich households will not increase their housing by much due to decreasing marginal utility.
- Housing price has to drop more to induce poor households not to sell their houses.

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
- Still insufficient drop in asset prices
- The literature is trying hard to get this (Midrigan and Philippon (2011), Guerrieri and Lorenzoni (2009)) with limited success.
- Still ways to go.

References

Fang, Lei and Jun Nie. 2013. "Education, Human Capital and U.S. Labor Market Dynamics." Presented at MidWest Macro Meetings.

Gornemann, Nils, Keith Kuester, and Makoto Nakajima. 2012. "Monetary Policy with Heterogeneous Agents." Mimeo, FRB Philadelphia.

Guerrieri, Veronica and Guido Lorenzoni. 2009. "Liquidity and Trading Dynamics." *Econometrica* 77 (6):1751–1790.

Midrigan, V. and T. Philippon. 2011. "Household Leverage and the Recession." NYU Working Paper FIN-11-038, New York University.