Macro-prudential Policy in a Fisherian Model of Financial Innovation

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US Financial Crisis: Facts and Policy Response

- Deep **financial innovation** since mid 90s:
  - New securities and trading technology
  - New regulatory and legal regime
- **Credit boom:** 97-06:
  - Household net debt: 35 to 70% of GDP
  - Residential land value: 50 to 75% of GDP
  - Leverage ratio: 64% to 93%
- Widespread view about key role of **irrational exhuberance** & **systemic risk**: $\rightarrow$ Calls for **macroprudential regulation**

Research Questions

- How does the interaction between optimistic beliefs, financial innovation and financial frictions contribute to the dynamics of credit booms and crashes?
- What are the implications of this interaction for the effectiveness of macro-prudential policy?
- What role does the structure and/or asymmetry of beliefs about stability of a new financial regime play?

$\rightarrow$ Need of a unified framework to answer these questions

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What we do

- Analyze role of macro-prudential policy in a Neo-Fisherian model:
  - Financial innovation triggers optimism about credit conditions causing increases in asset prices and leverage
  - Sudden financial shock triggers fire-sales and deleveraging
- Compare decentralized equilibrium with learning with financially efficient planner:
  - Planner internalizes that increase in leverage leads to feedback loop between asset prices and financial constraints. Therefore, it borrows less during the credit boom and experiences milder credit crunch
- Study effects of asymmetry of beliefs between agents and regulators

Some Related Literature

- **Optimism in credit cycles:** (Shiller (2005), Reinhart and Rogoff (2008), Gorton (2008), Geanakoplos (2009), Fostel-Geanakoplos (2008), Cao (2010) ,Gennaioli-Shleifer-Vishny (2011), Boz-Mendoza (2010), Simsek (2010))
- **Macroprudential policy:** (Caballero-Krishnamurthy (2003), Lorenzoni (2007), Bianchi (2011), Stein (2011), Bianchi-Mendoza (2010), Korinek (2010), Jeanne-Korinek (2010), Benigno et al. (2010), Woodford (2011))
- **Generic Inefficiency Incomplete Markets:** (Stiglitz (1983), Geanakoplos-Polemarchakis(1986), Geanakoplos-Magill-Quinzii (1990))

Our Contribution: Develop DSGE framework to study interaction between credit frictions, optimism and macro-prudential policy

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Model Features

- Off-the-shelf asset pricing model with incomplete markets & and asset in fixed supply
- Small open economy populated by identical households (or partial eq. model of collateralized household debt (e.g. mortgages))
- Households borrow in a one-period non-state contingent bond
- Collateral constraint limits debt to fraction of market value of land
- Fin. innovation increases debt limit but also introduces risk of regime switching

Model

Each of a continuum of identical households solve:

$$\max_{b_{t+1},k_{t+1},c_{t+1}} E_0^{s} \left[\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \right]$$

subject to the budget constraint:

$$q_t k_{t+1} + c_t + \frac{b_{t+1}}{R} = q_t k_t + b_t + \varepsilon_t f(k_t)$$

and a collateral constraint:

$$-\frac{b_{t+1}}{R} \leq \kappa_t q_t k_{t+1}.$$

where κ_t represent a stochastic loan-to-value ratio

Learning Problem (Cogley and Sargent 2008)

- κ_t follows a two-state Markov process with values κ^L, κ^H and "true" transition matrix: $\begin{bmatrix} F_{hh} & 1-F_{hh} \\ 1-F_{ll} & F_{ll} \end{bmatrix}$.
- Agents learn in a Bayesian fashion about transition matrix by observing realizations of κ's.
  - Agents have independent beta priors over (F_{hh}, F_{ll})

    $\rightarrow$ Posterior are given by:

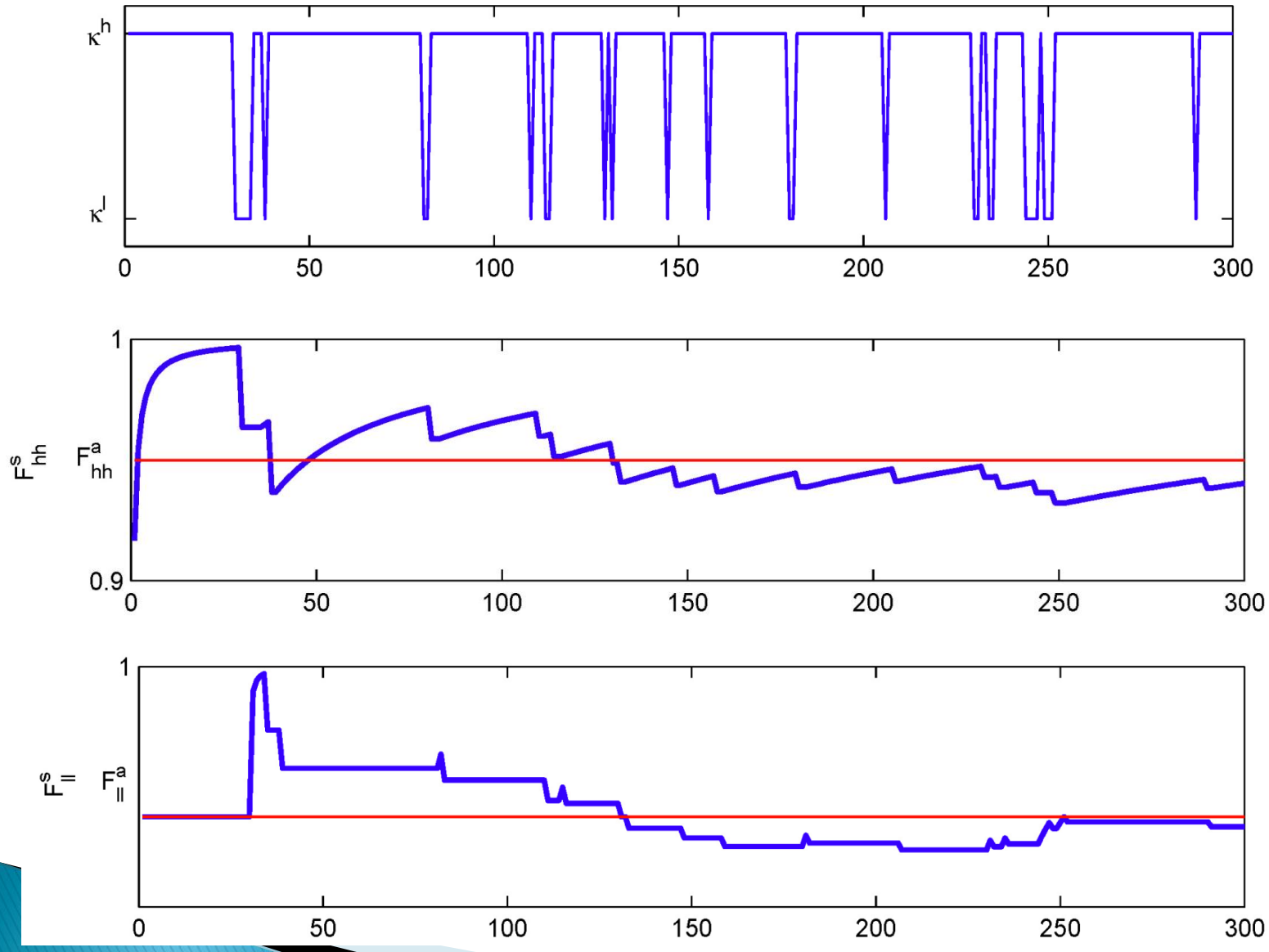
$$E_t[F^s_{hh}] = \frac{n^{hh}_t}{n^{hh}_t + n^{hl}_t} \qquad E_t[F^s_{ll}] = \frac{n^{ll}_t}{n^{ll}_t + n^{lh}_t}$$

    where n^{ij}_t be the number of transitions from state κ^i to κ^j
- Focus on Recursive Anticipated Utility problems (AUOP).

Key Features of Learning Process

- Converges to true probabilities in the long run
- Beliefs about a regime are updated only when observing that regime
- Initial priors drive speed at which optimism or pessimism build with first realizations

Example of learning dynamics



$$F^a_{hh} = 0.95$$
$$F^a_{ll} = 0.5$$
$$Beta(0.1, 0.1)$$

Asset Pricing Conditions

Land premium:

$$E_t^s[R_{t+1}^q] - R = \frac{\mu_t(1-\kappa) - Cov_t^s(\beta u'(c_{t+1}), R_{t+1}^q - R)}{\beta E_t^s u'(c_{t+1})}$$

Forward solution for asset prices

$$q_t = E_t^s \sum_{j=0}^{\infty} \frac{\varepsilon_{t+j+1} f'(\overline{K})}{\prod_{i=0}^{j} E_{t+i} R_{t+1+i}^q}$$

Remark: Asset prices include discounted payoffs + collateral value

and the return on land is by definition:

$$R_{t+1}^q \equiv \frac{\varepsilon_t f'(\overline{K}) + q_{t+1}}{q_t}$$

Fisherian Deflation when constraint binds

A tightening of the constraint leads to increase in excess returns

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and a tightening of the collateral constraint $b_{t+1} \leq \kappa_t q_t k_{t+1}$

which feeds back to asset prices

Expectations and Fisherian Deflation

Optimism: During the credit boom, a lower subjective belief about switching from κ^H to κ^L lowers Covariance Term

$$E_t^s[R_{t+1}^q] - R = \frac{\mu_t(1-\kappa) - Cov_t^s(\beta u'(c_{t+1}), R_{t+1}^q - R)}{\beta E_t^s u'(c_{t+1})}$$

This raises asset prices and relaxes collateral constraints

Expectations and Fisherian Deflation

Pessimism: During the credit bust, a higher subjective belief about remaining at κ^L increases Covariance Term

$$E_t^s[R_{t+1}^q] - R = \frac{\mu_t(1-\kappa) - Cov_t^s(\beta u'(c_{t+1}), R_{t+1}^q - R)}{\beta E_t^s u'(c_{t+1})}$$

This depresses asset prices and tightens collateral constraints

Analysis of Macro-prudential Policy

- Feedback between beliefs, asset prices and collateral creates classic Fisherian amplification mechanism operating in the upswing of a credit boom and in the crash.
- Two benchmarks planners:
  - Uninformed: shares same beliefs as private agents
  - Informed: knows true transition probabilities
- Planners subject to the same set of feasible credit positions as learning or full info decentralized equilibria (akin to Kehoe-Levine's financial efficiency)

Constrained Planners' Problems

Planners maximize

$$E_0^i \left[\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \right] \qquad \text{for} \quad i = SP^U, SP^I$$

subject to

$$c_t + \frac{b_{t+1}}{R_t} = b_t + f(\overline{K})$$

and

$$-\frac{b_{t+1}}{R_t} \leq \kappa_t q_t^i \overline{K}$$

- $SP^U : E^i = E^s$ and $q_t^i = q_t^{DEL}$
- $SP^I : E^i = E$ and $q_t^i = q_t^{DEF}$

Euler Equation for Bonds

Decentralized Equilibrium:

$$u'\left(c_t(b,\varepsilon,\kappa)\right) - \mu_t(b,\varepsilon,\kappa) = \beta R E_t^i \left[u'(c_t(b',\varepsilon',\kappa')) \right]$$

Euler Equation for Bonds

Social Planner:

$$u'\left(c_t(b,\varepsilon,\kappa)\right) - \mu_t(b,\varepsilon,\kappa) =$$
$$\beta R E_t^i \left[u'(c_t(b',\varepsilon',\kappa')) + \kappa' \mu_t(b',\varepsilon',\kappa') \frac{\partial q_t^i(t+1)}{\partial b'} \right]$$

with expectations formed according to information set assumed to be available

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Macro-prudential Tax on Debt

$$\tau^i_{b,t} = \underbrace{\frac{E^i_t[u'(t+1)]}{E^s_t[u'(t+1)]} - 1}_{\text{information}} + \underbrace{\frac{E^s_t\left[\kappa_{t+1}\mu_t(t+1)\frac{\partial q^i_t(t+1)}{\partial b'}\right]}{E^s_t[u'(t+1)]}}_{\text{externality}} + \underbrace{\frac{E^i_t\left[\kappa_{t+1}\mu_t(t+1)\frac{\partial q^i_t(t+1)}{\partial b'}\right] - E^s_t\left[\kappa_{t+1}\mu_t(t+1)\frac{\partial q^i_t(t+1)}{\partial b'}\right]}{E^s_t[u'(t+1)]}}_{\text{interaction}}$$

Financial Innovation Experiment

- Pre-financial innovation: Before 1997, regime with constant κ^l but stochastic TFP
- Financial Innovation: 1997Q1, introduction of regime with two possible values of κ and first realization of κ^h
  - First publicly available securitization of CRA loans.
  - Net credit assets-GDP ratio started to fall in 1997.
- Financial crisis: 2007Q1, first realization of κ^l. Early stages of the subprime mortgage crisis in Fall 2006.
- Learning period of $T = 48$ quarters, first 40 with κ^h and remaining 8 with κ^l.

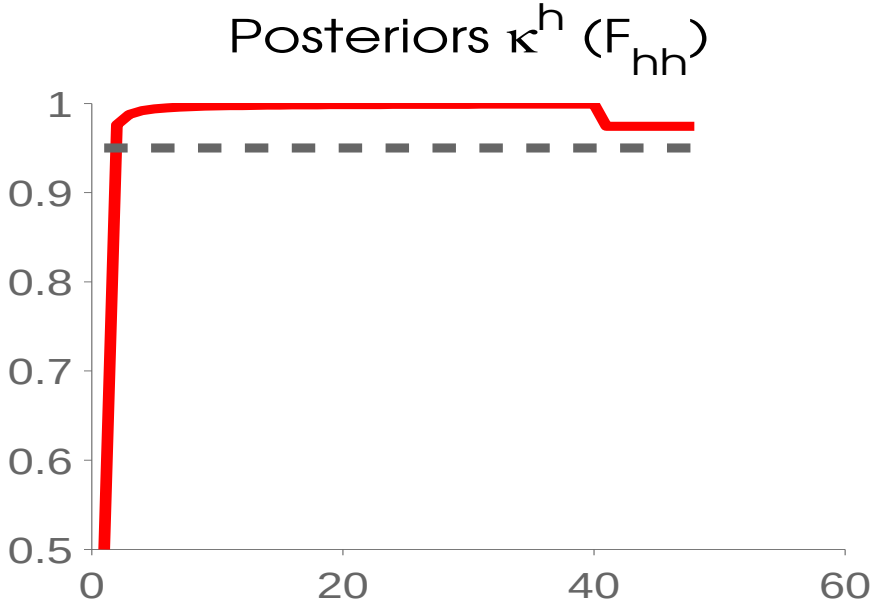
Calibration

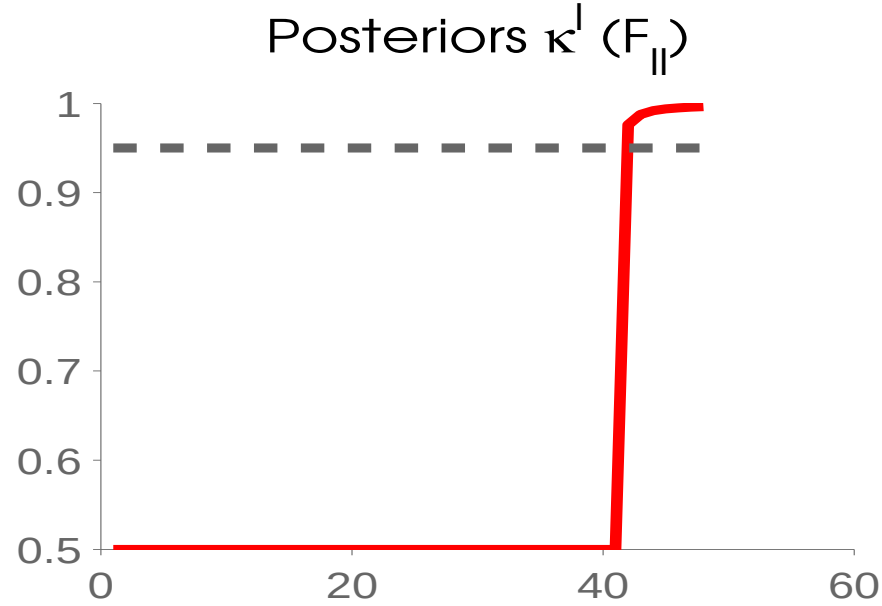
β	Discount factor (annualized)	0.91
σ	Risk aversion coefficient	2.0
c	Consumption GDP ratio	0.673
A	Lump-sum absorption	0.321
r	Interest rate (annualized)	2.660
ρ	Persistence of endowment shocks	0.869
σ_e	Standard deviation of TFP shocks	0.008
α	Factor share of land in production	0.025
l	Supply of land	1.0
κ^h	Value of κ in the high securitization regime	0.926
κ^l	Value of κ in the low securitization regime	0.642

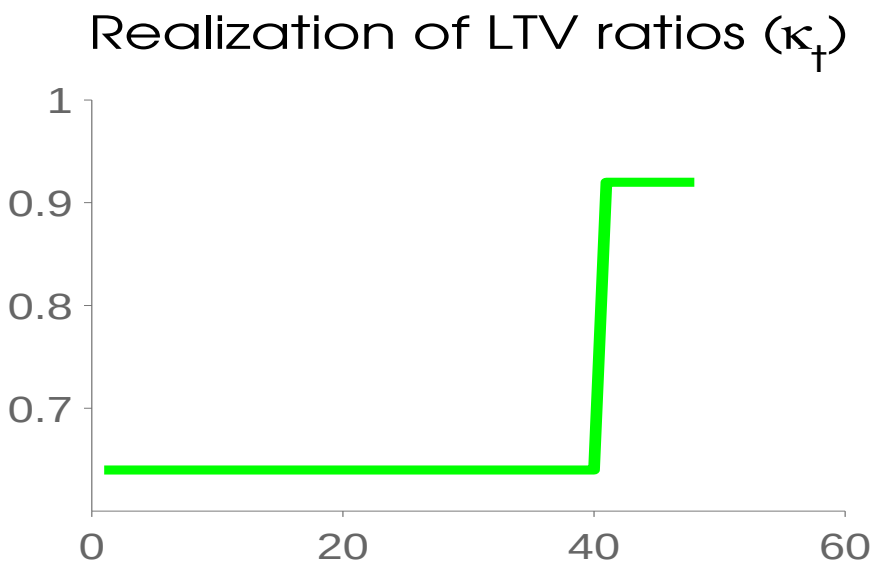
Initial Priors and True Probabilities in Baseline

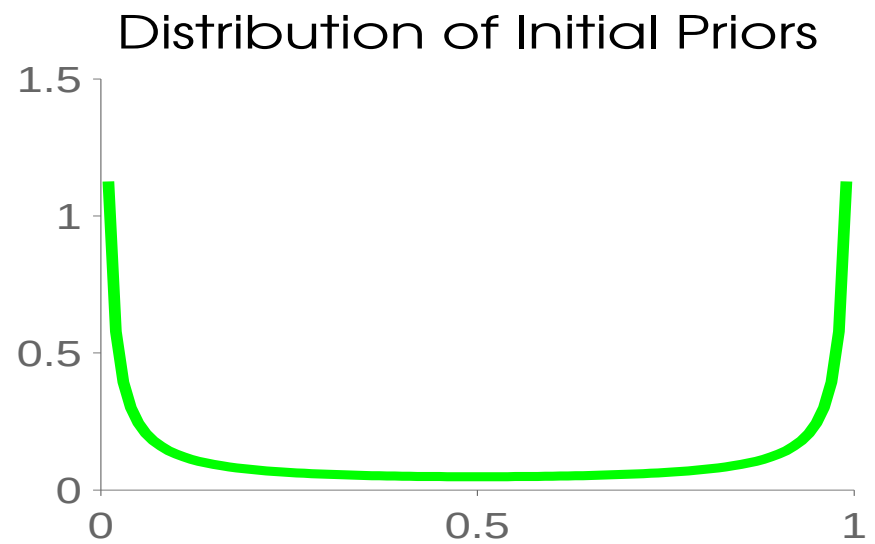
		Value
F^a_{hh}	True persistence of κ^h	0.964
F^a_{ll}	True persistence of κ^l	0.964
n_0^{hh}	Counter, high-to-high	0.0205
n_0^{hl}	Counter, high-to-low	0.0205
n_0^{lh}	Counter, low-to-high	0.0205
n_0^{ll}	Counter, low-to-low	0.0205

Evolution of Posteriors in Baseline 1



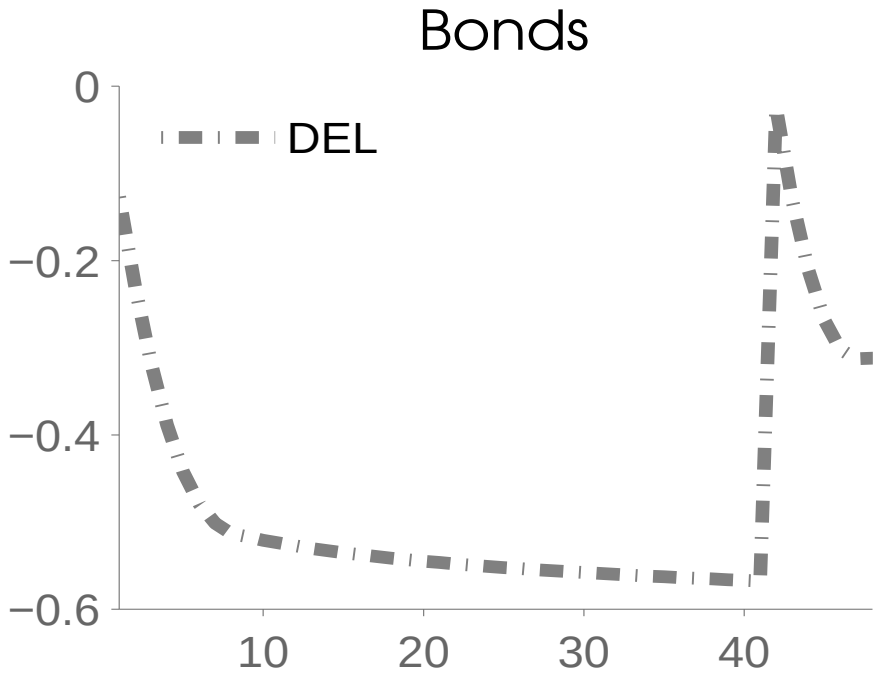






Findings in Baseline 1

- **Decentralized equilibrium** experiences boom in asset prices and surge in borrowing. Large optimism leads to credit constraint to become binding at early states of liberalization $\Rightarrow$ High Shadow Value from relaxing the constraint
- **Uninformed Planner** (SP^U) does not alter significantly macro time-series: Optimism builds quickly and collateral constraint becomes binding at early stages.
- **Informed Planner** (SP^I) takes significantly less debt and moderates increase in asset prices relative to decentralized equilibrium.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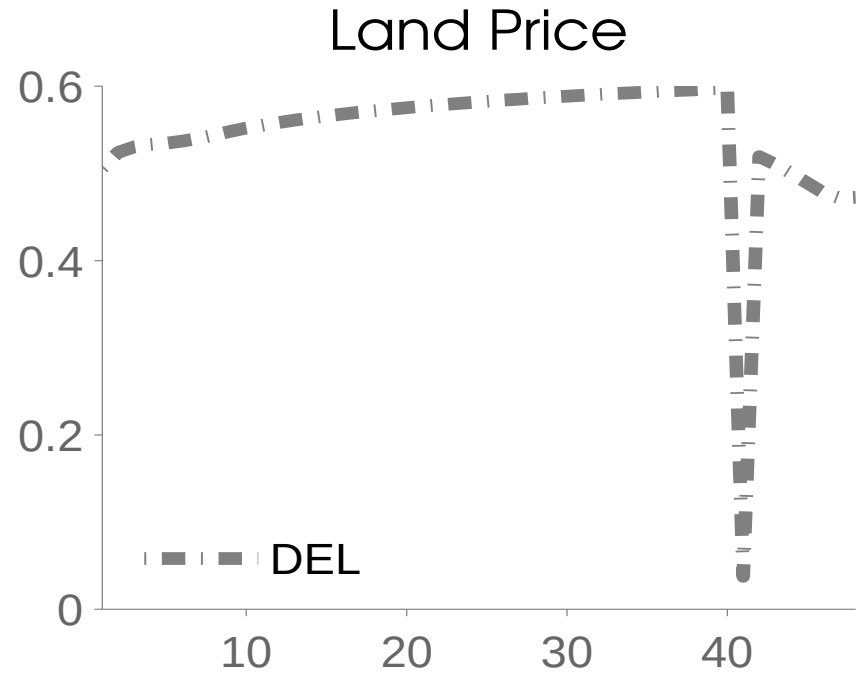
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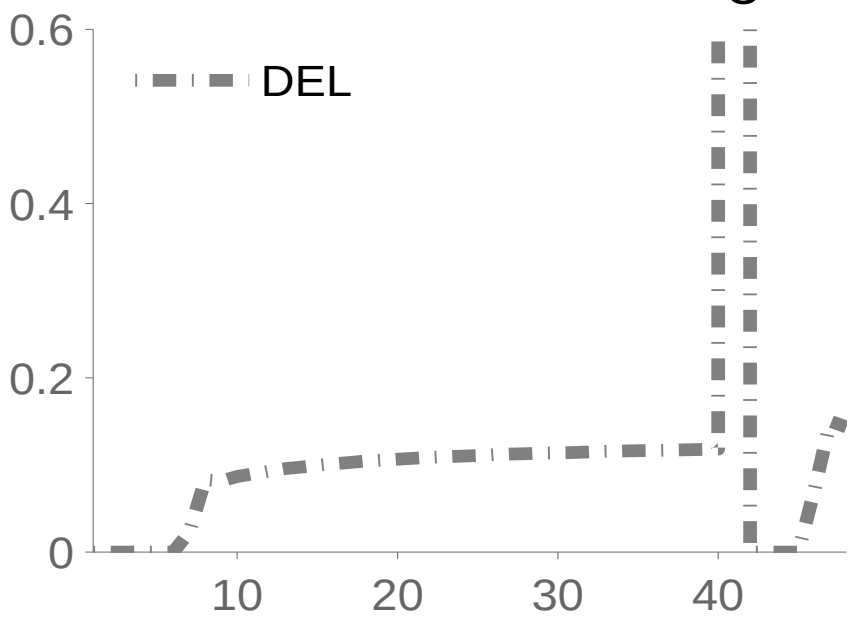
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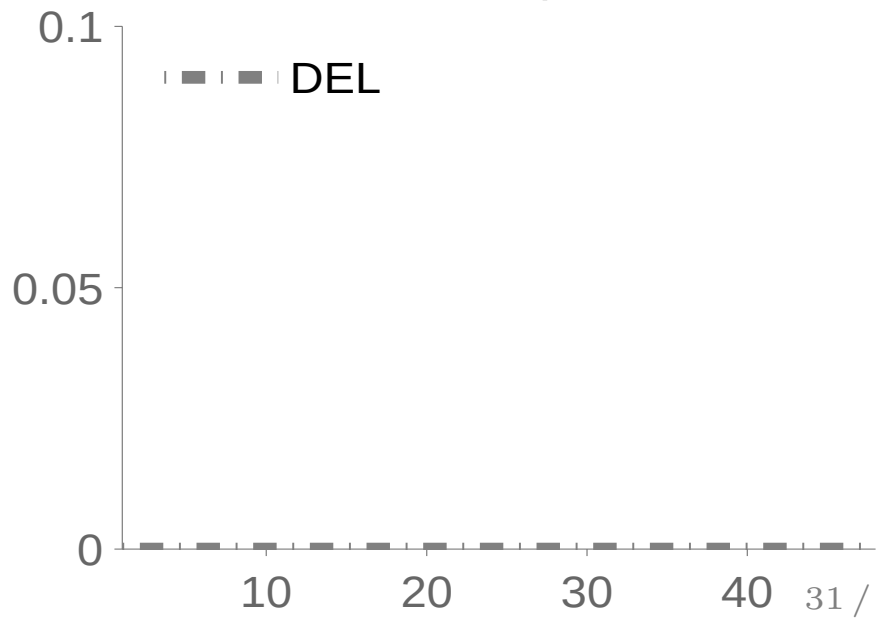
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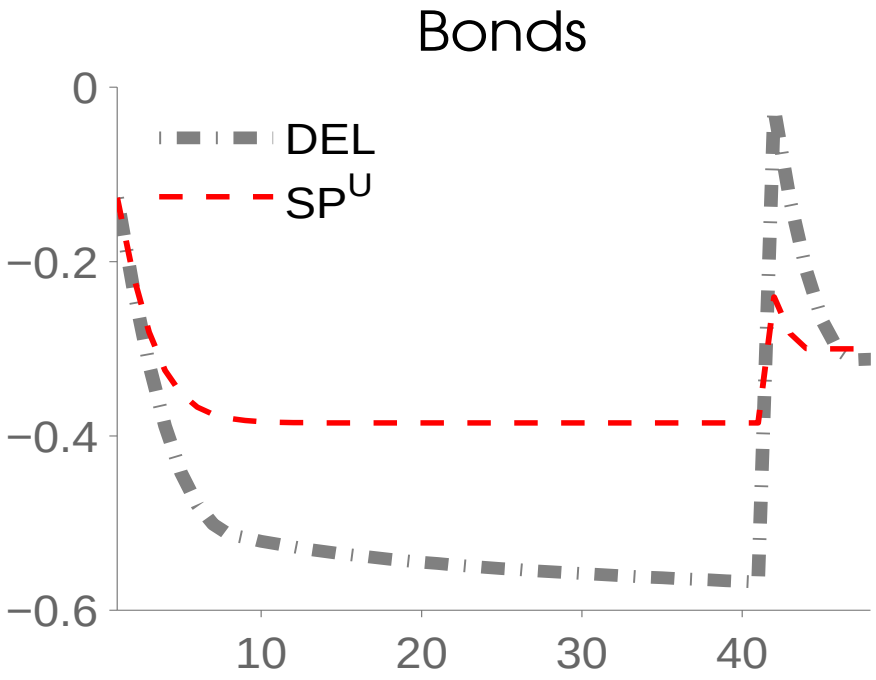
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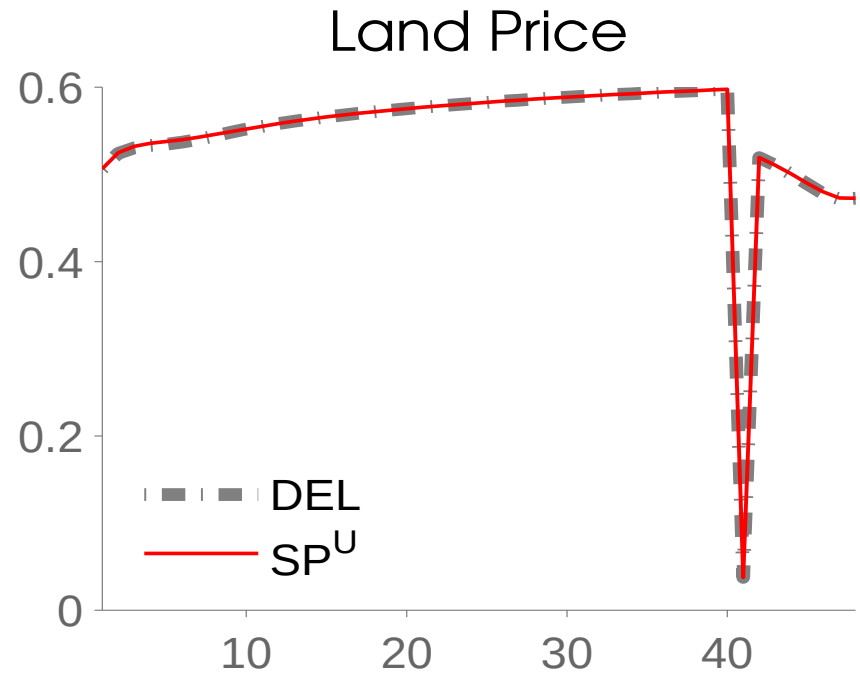
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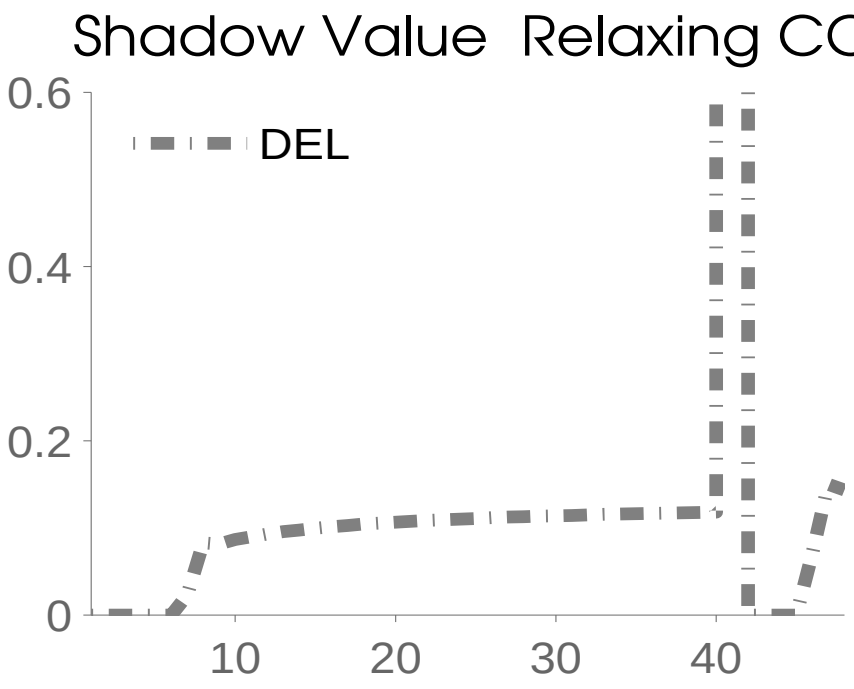
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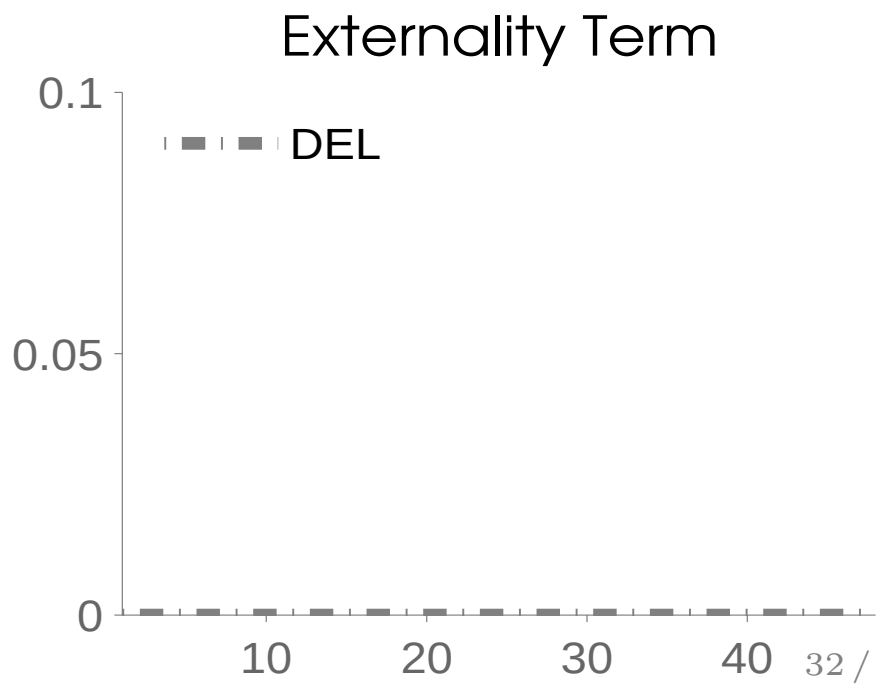
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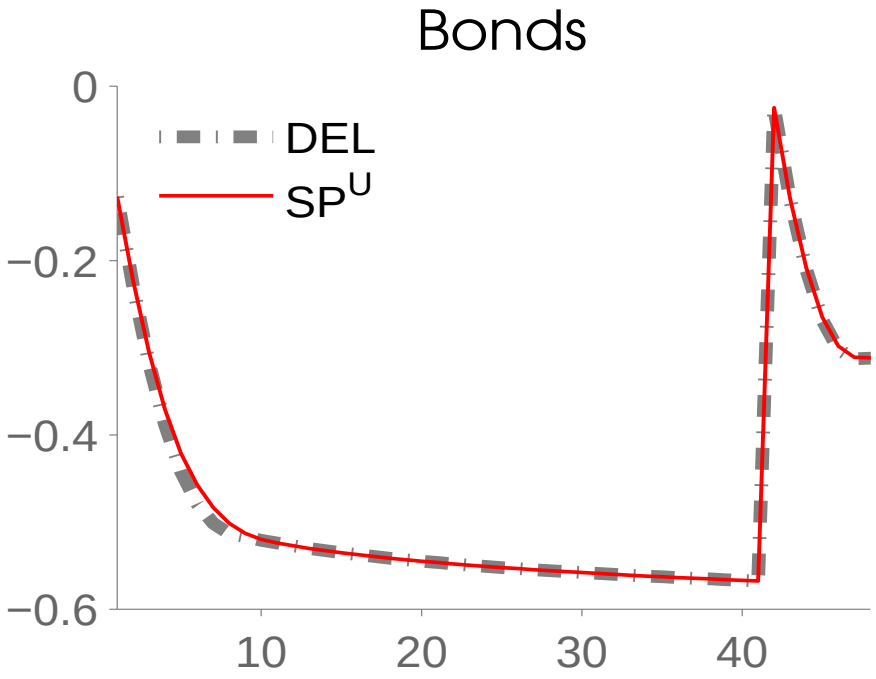
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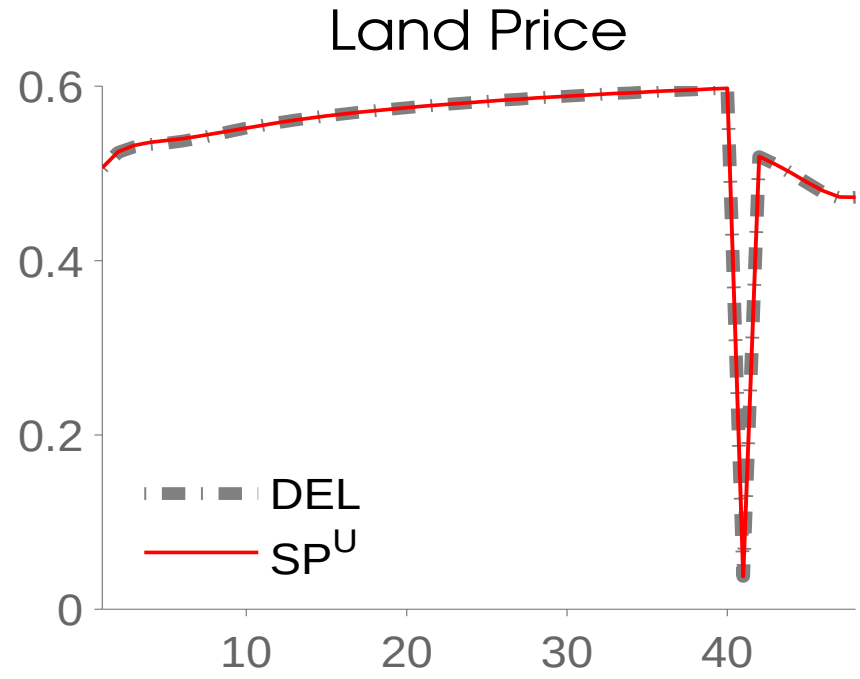
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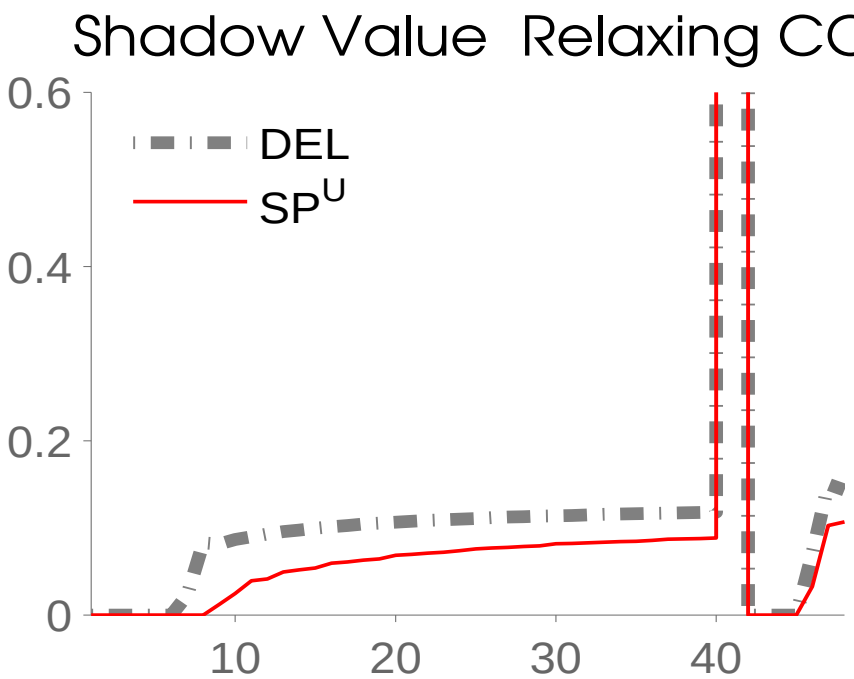
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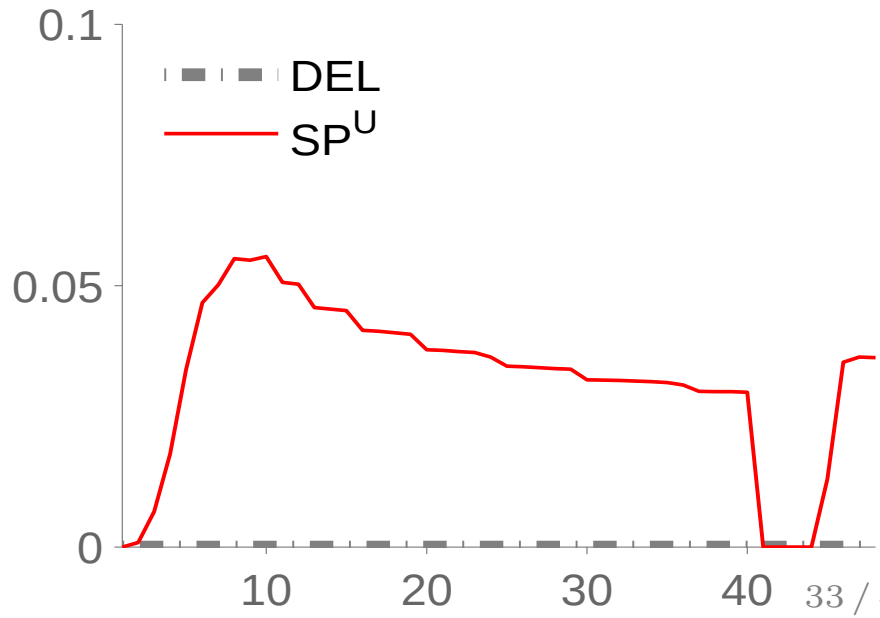
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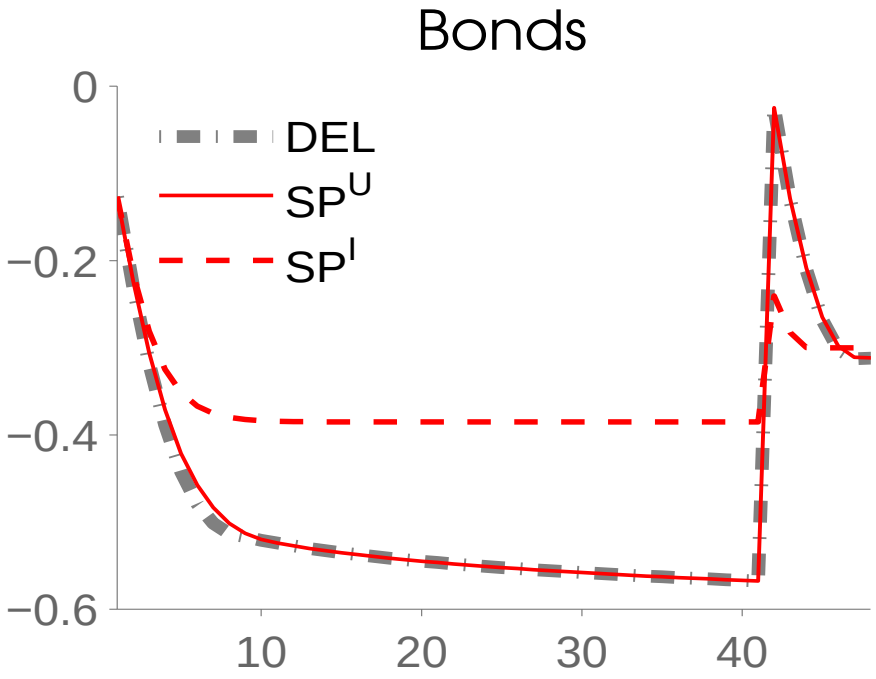
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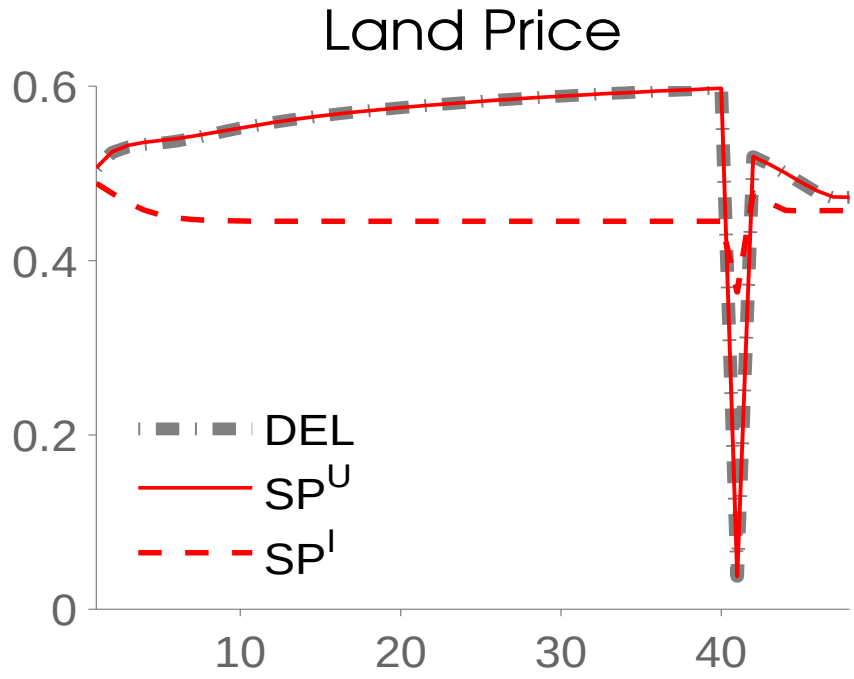
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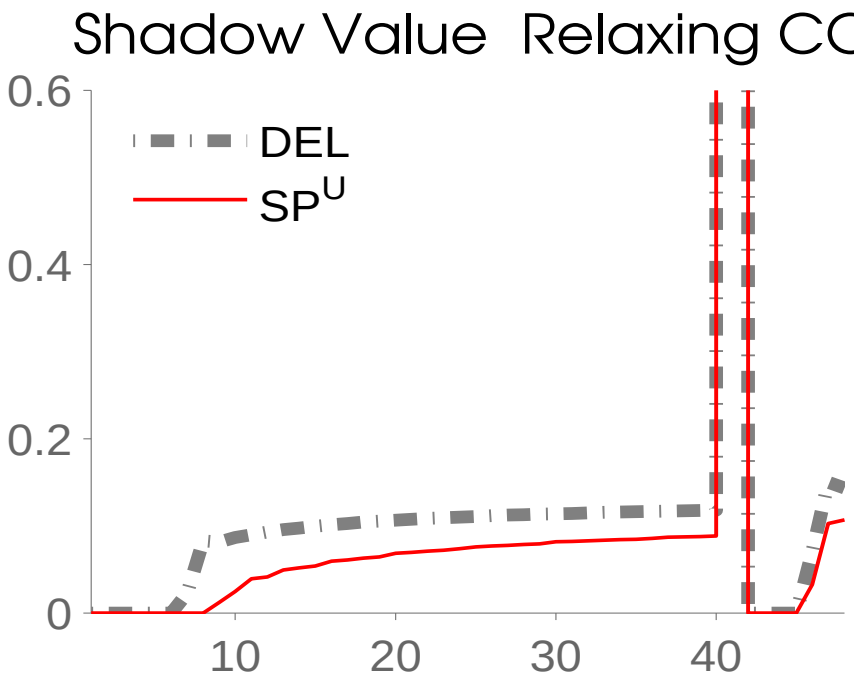
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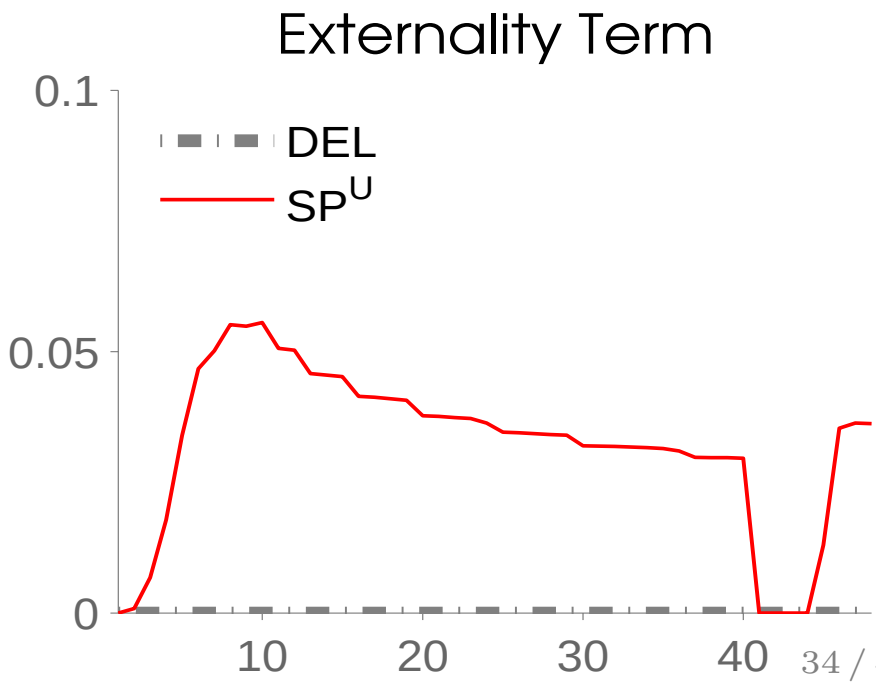
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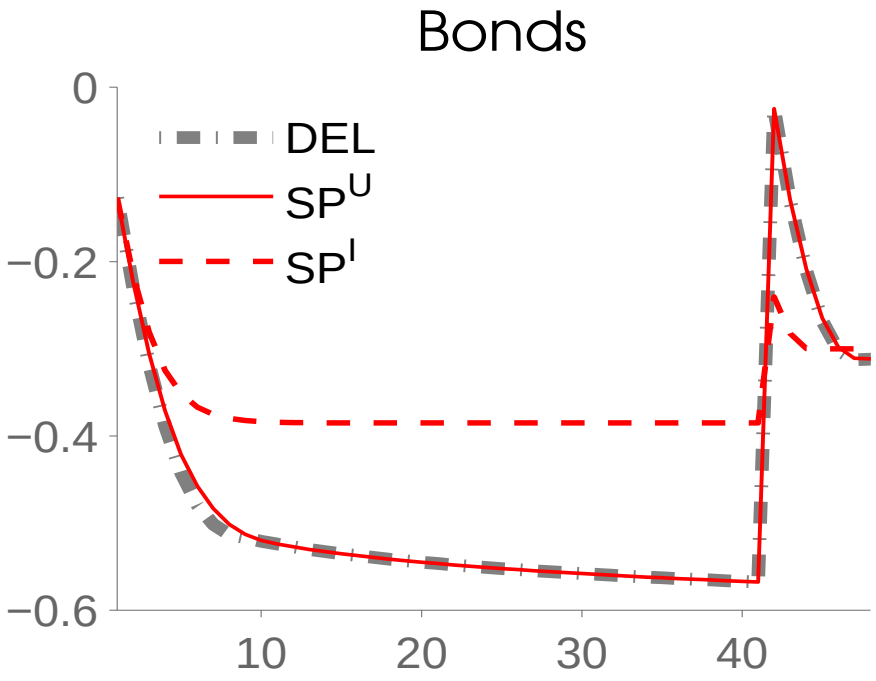
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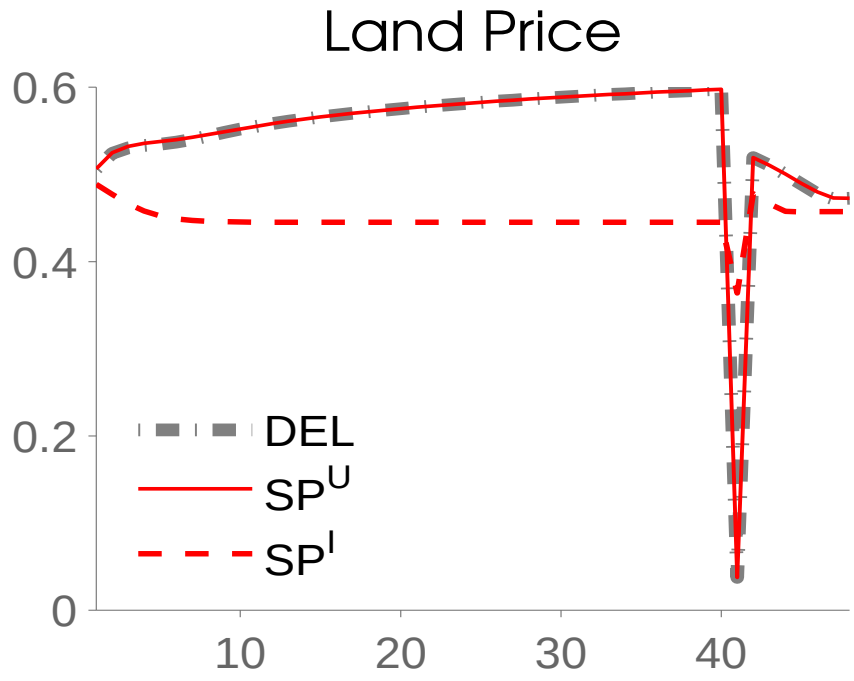
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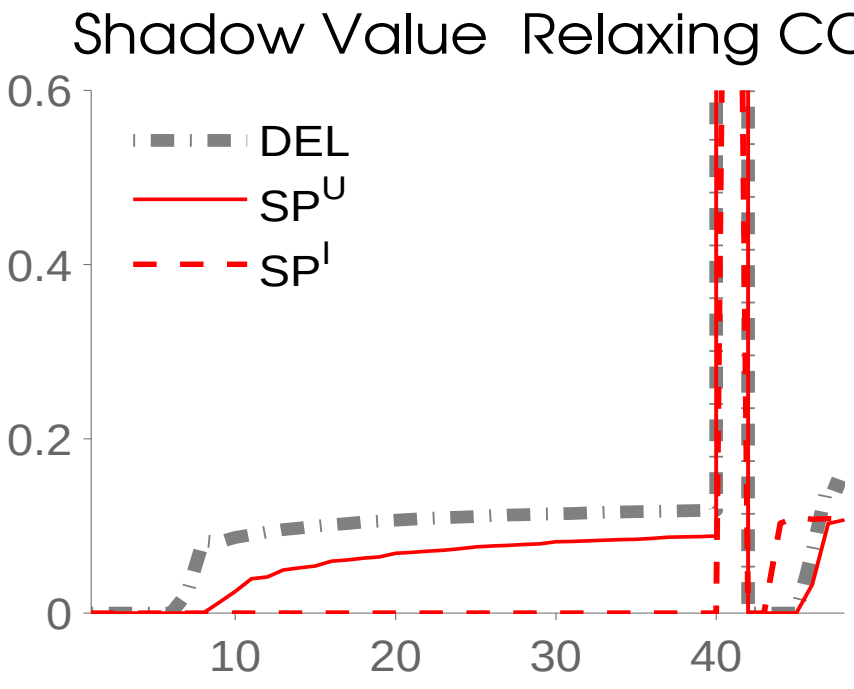
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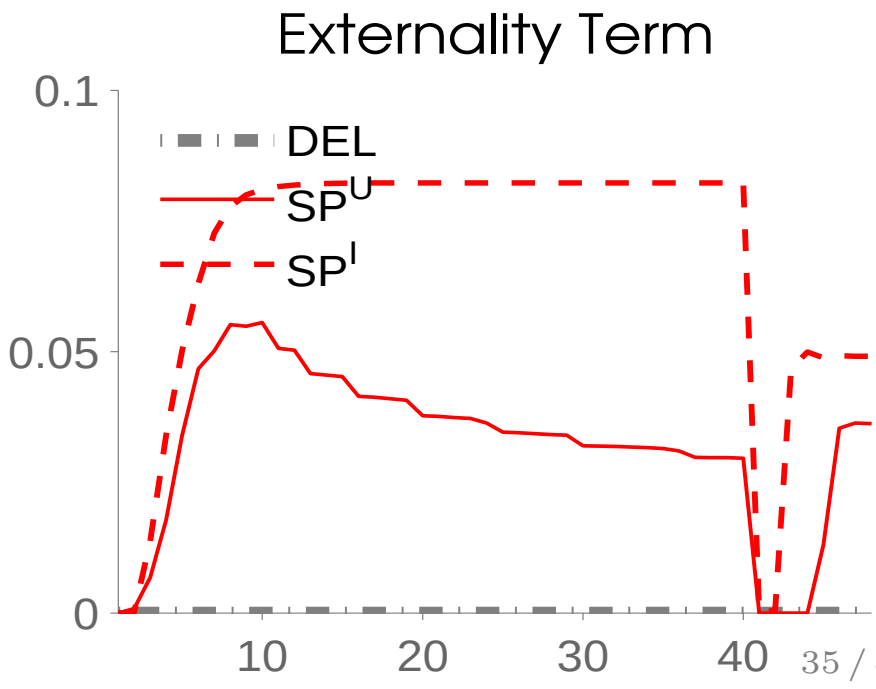
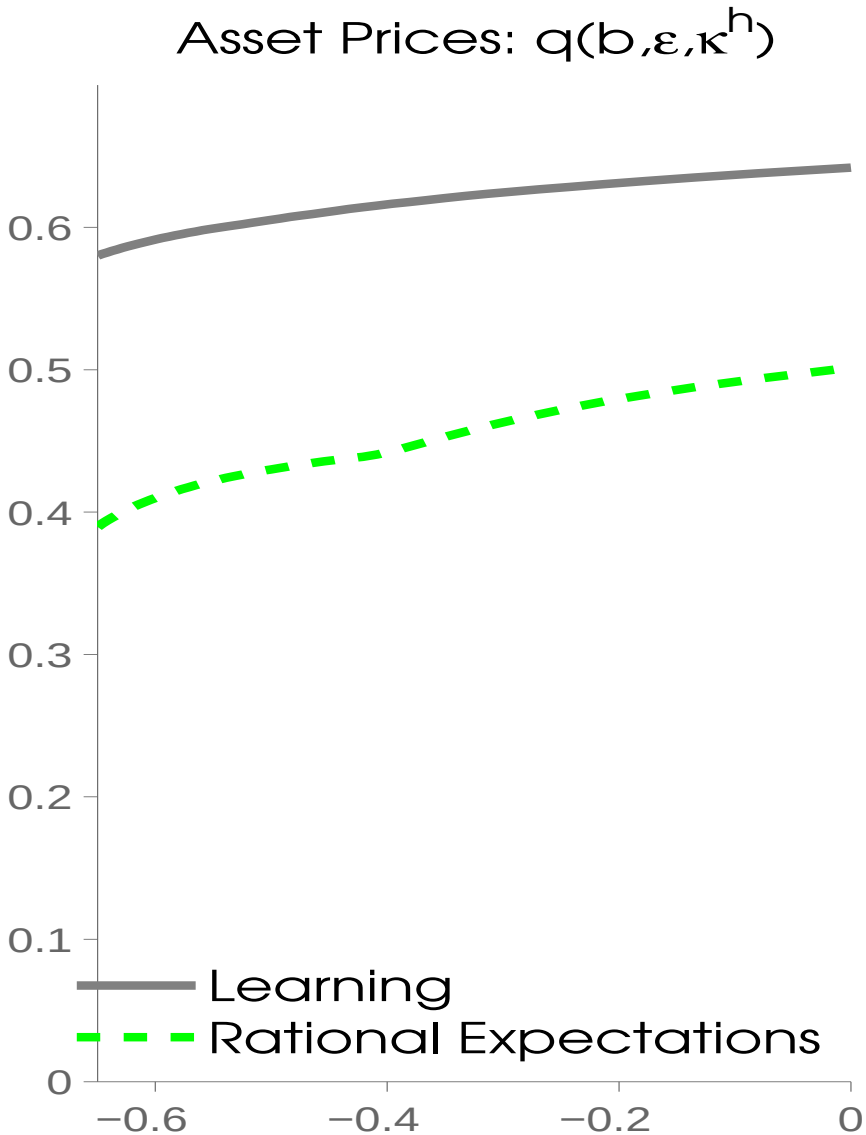
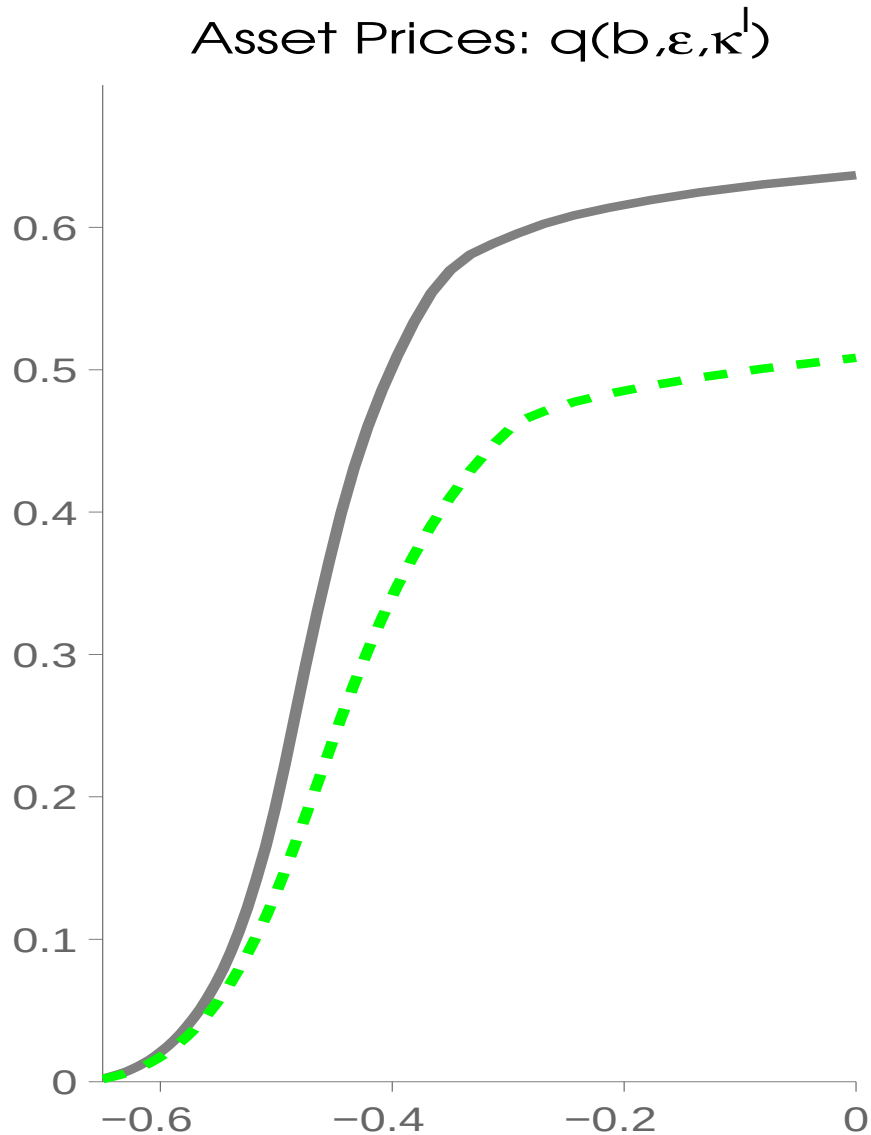
SP^U
SP^I

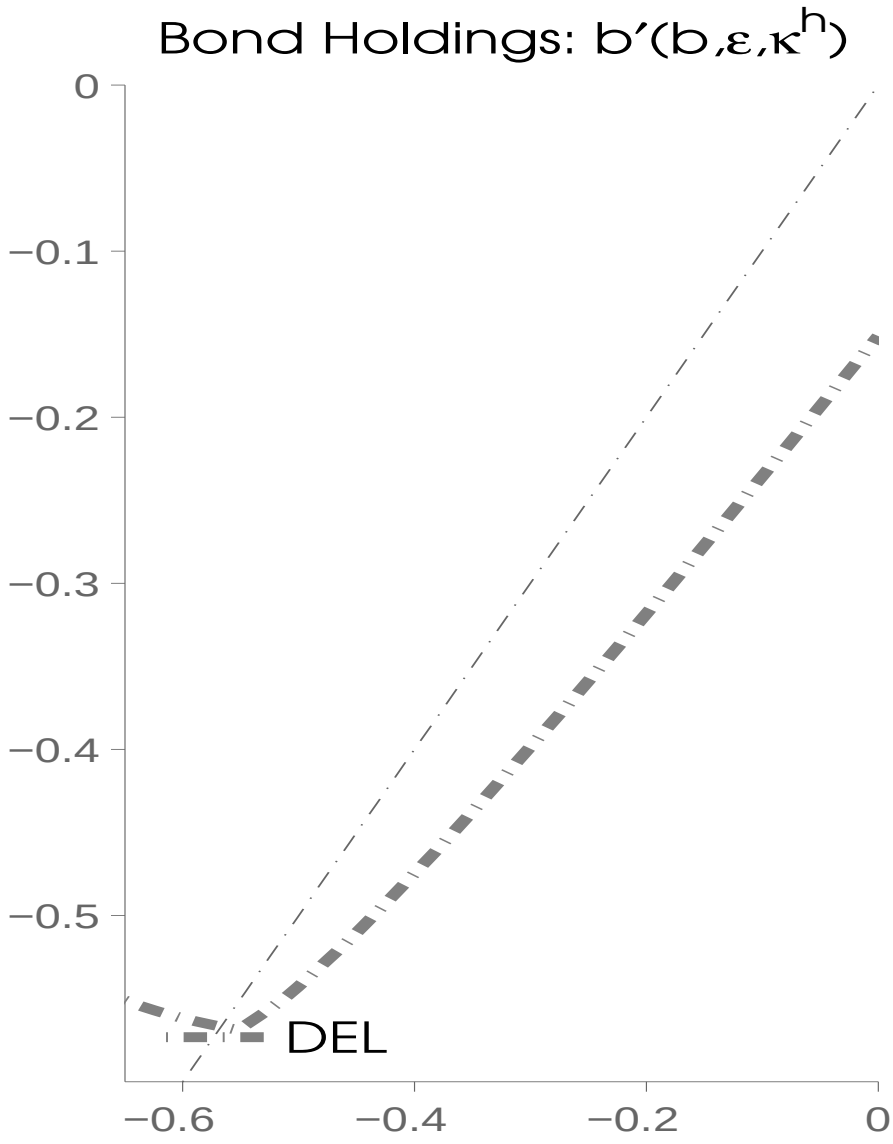

Externality Term
0.1
0.05
0
10
20
30
40
DEL
SP^U
SP^I

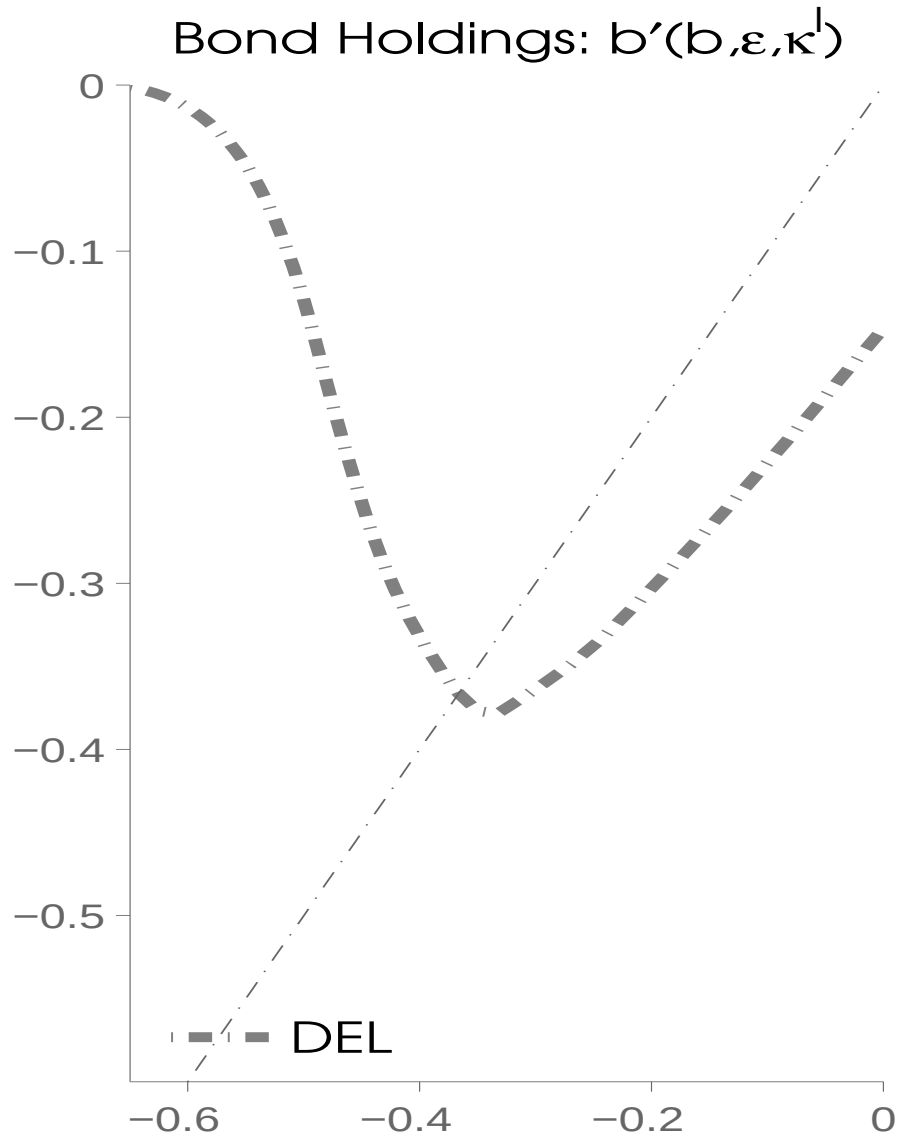
Asset Prices at Peak of Optimism



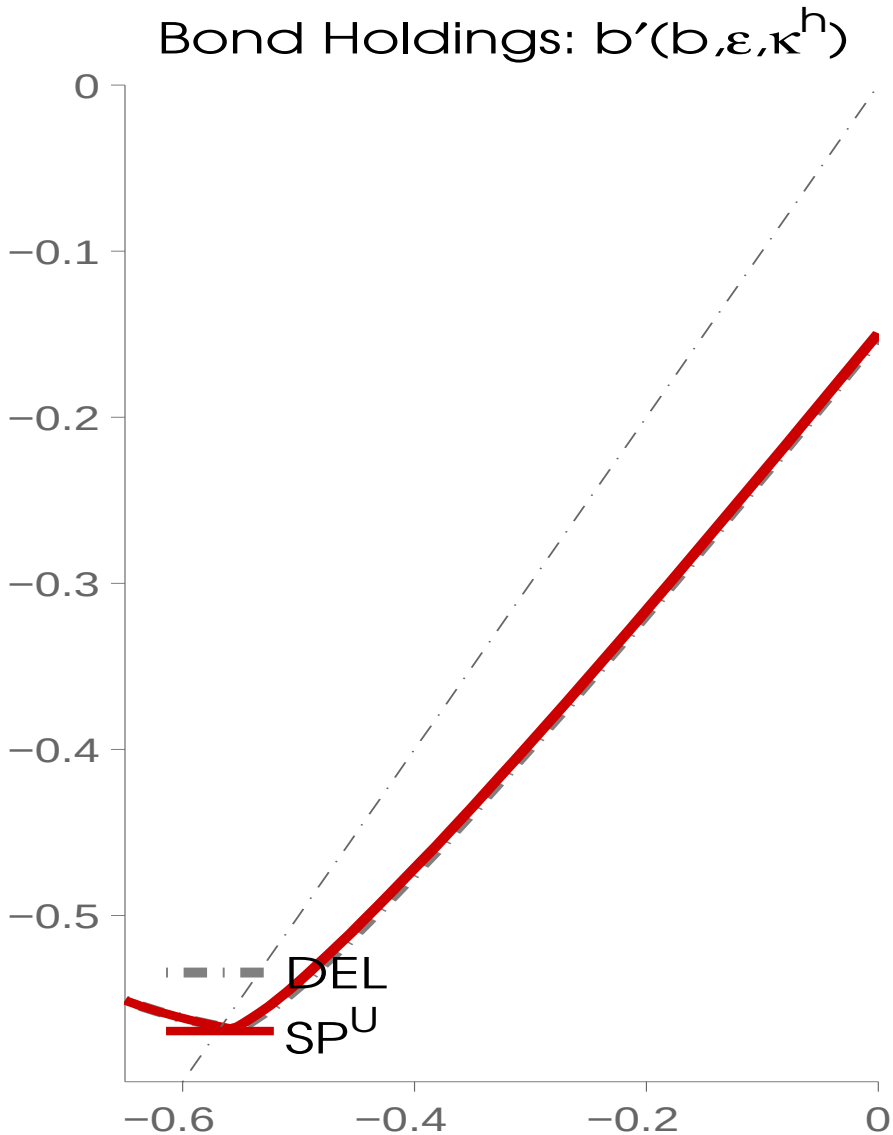


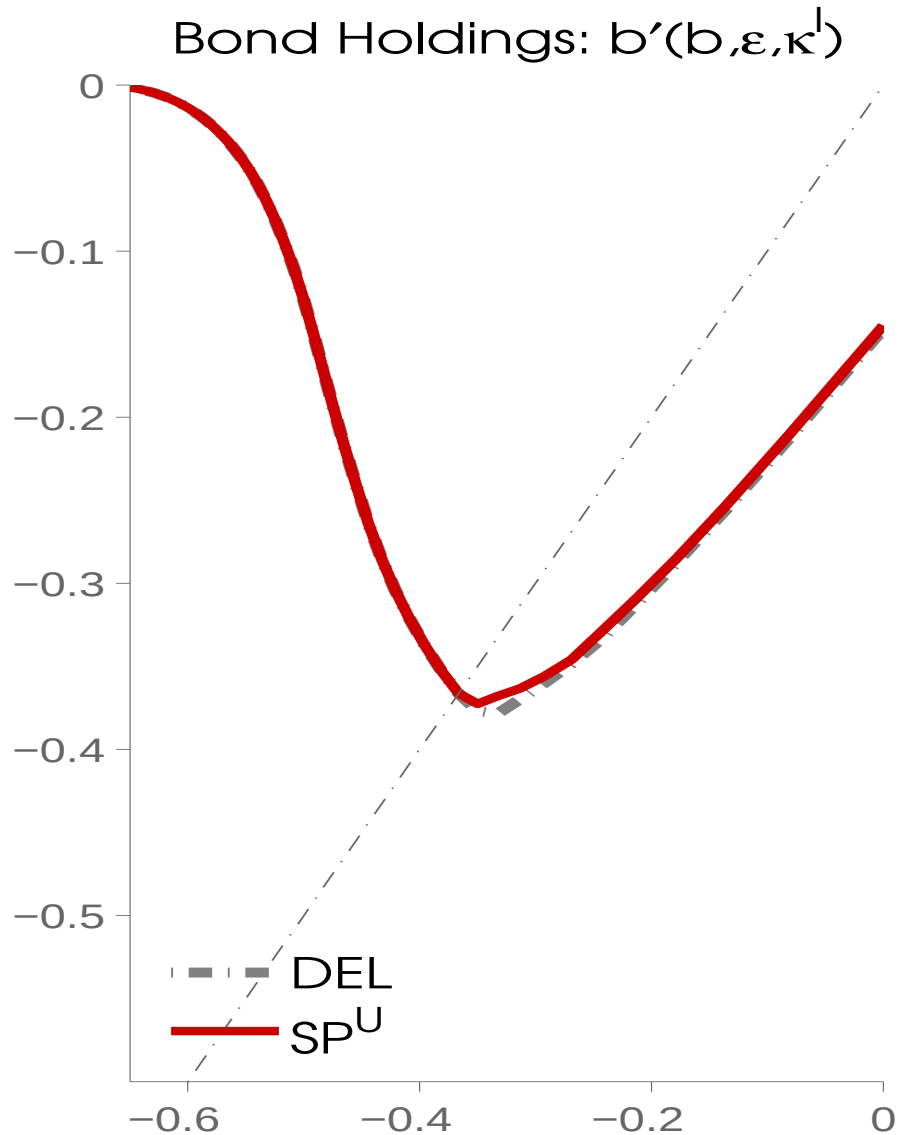
Bond Holdings at Peak of Optimism



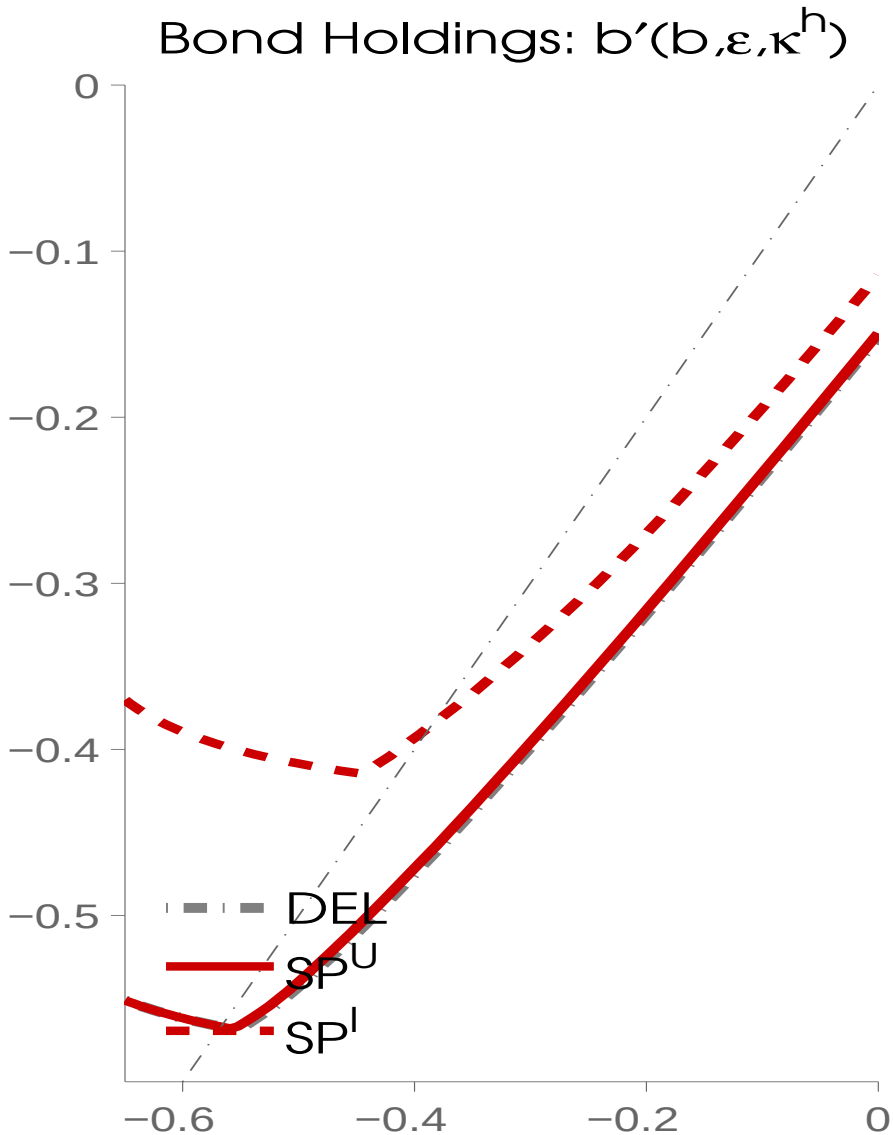


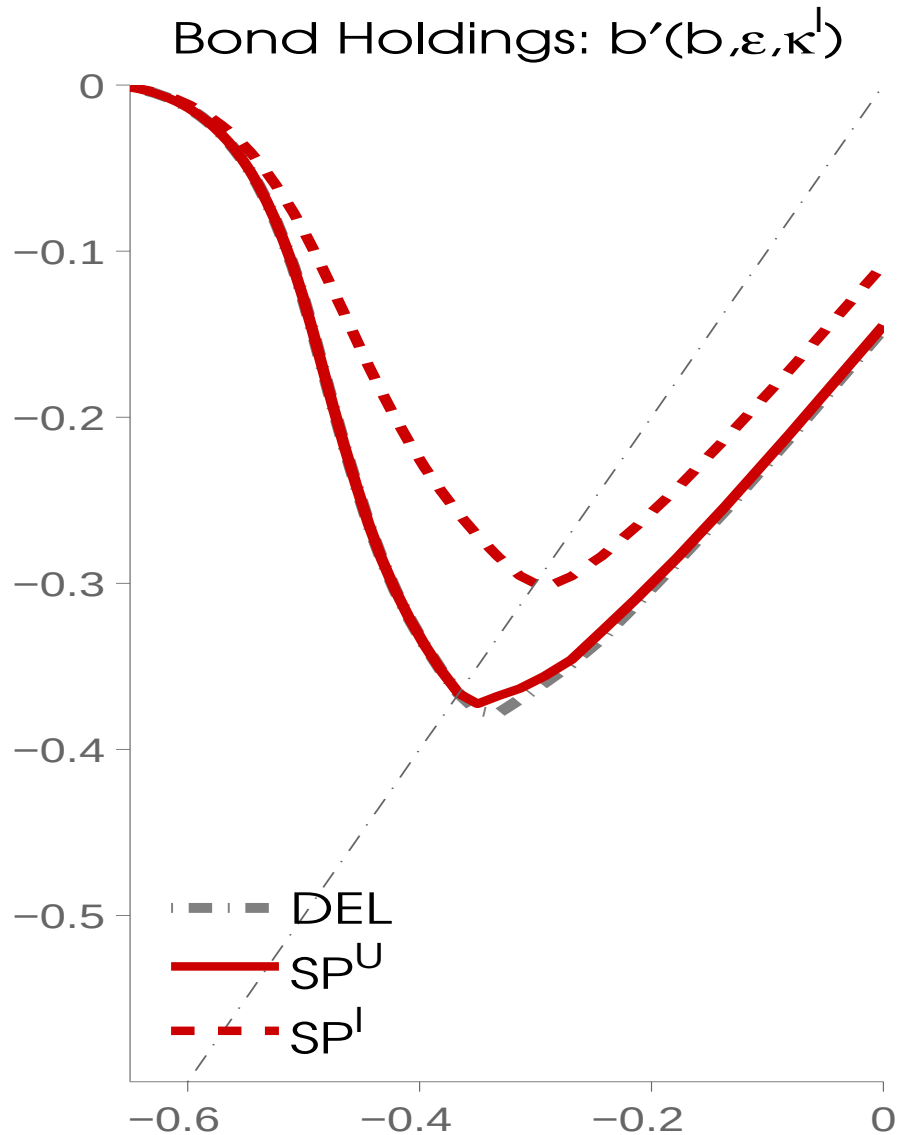
Bond Holdings at Peak of Optimism





Bond Holdings at Peak of Optimism



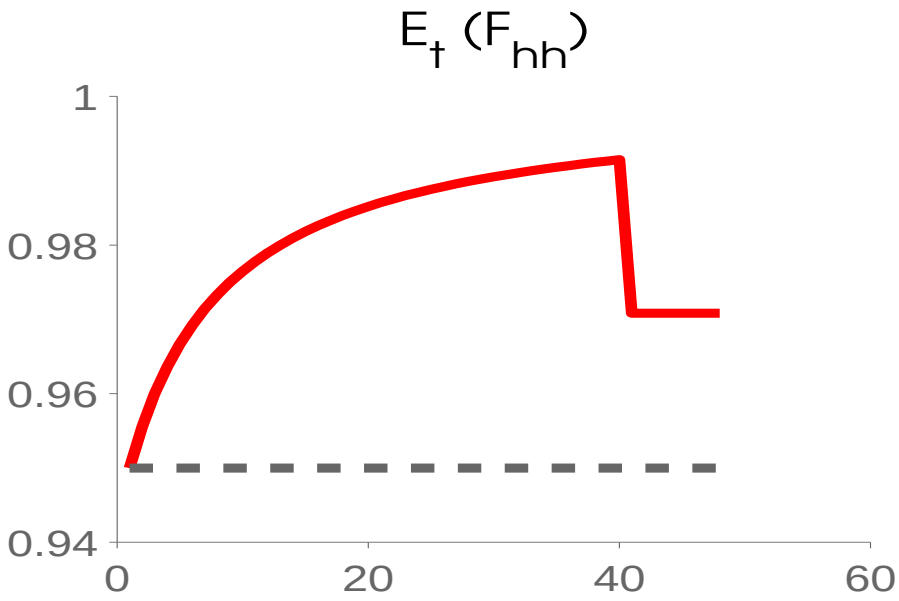


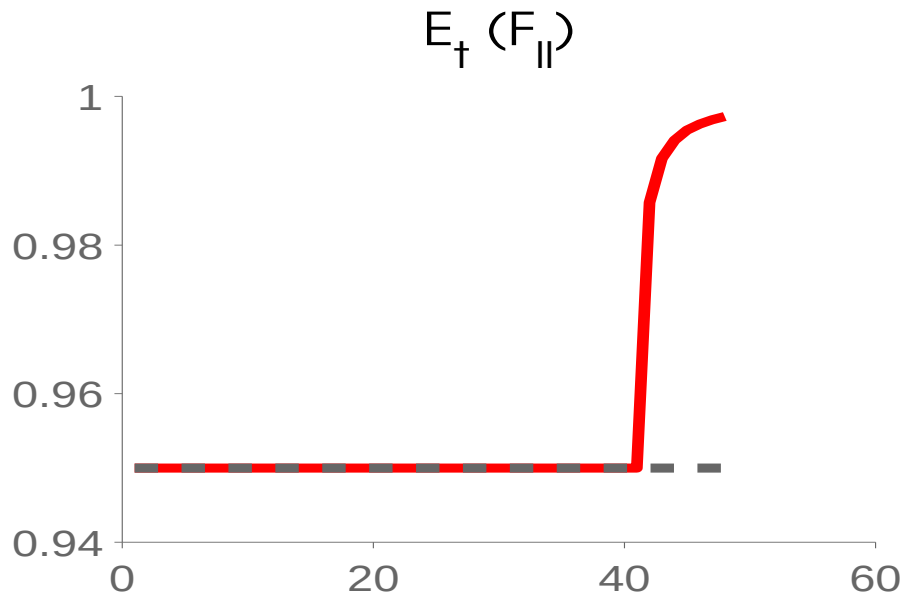
Welfare Gains

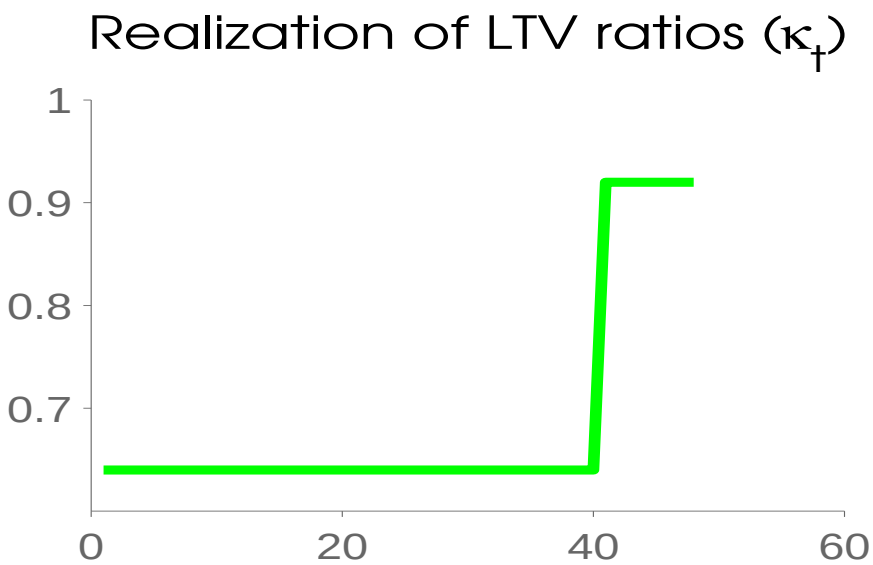
	Average		$(b_t^{DEL}, \kappa_t, \varepsilon_t)$	
	$t=1$	$t=40$	$t=1$	$t=40$
True probabilities				
(1) SP2 versus DEF	0.052	0.05	0.06	0.07
(2) SP2 versus DEL	0.37	7.4	0.30	7.39
(3) SP1 versus DEL	0.17	0.03	0.17	0.03
Subjective beliefs				
(4) SP1 versus DEL	0.025	0.0	0.025	0.0
(5) DEL versus SP2	-0.39	-2.7	-0.27	-2.73

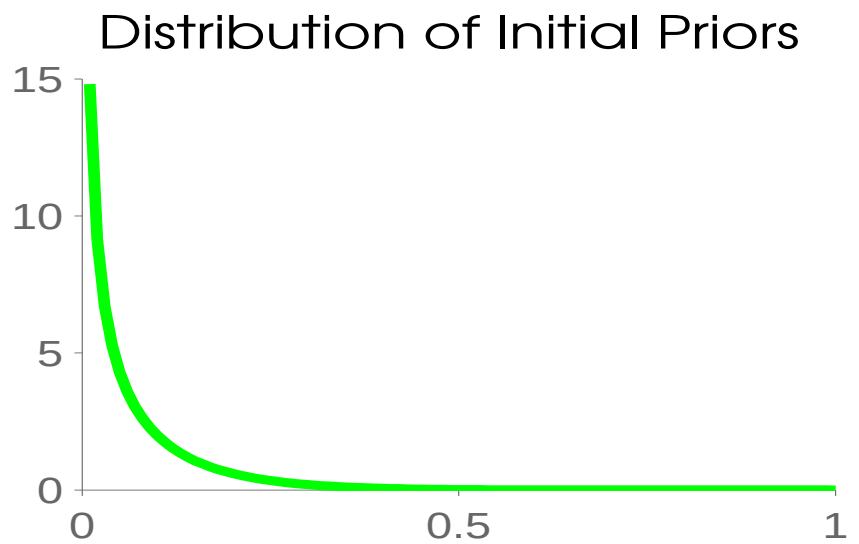
Sensitivity Analysis: Gradual Optimism Scenario

Evolution of Posteriors in Gradual Optimism

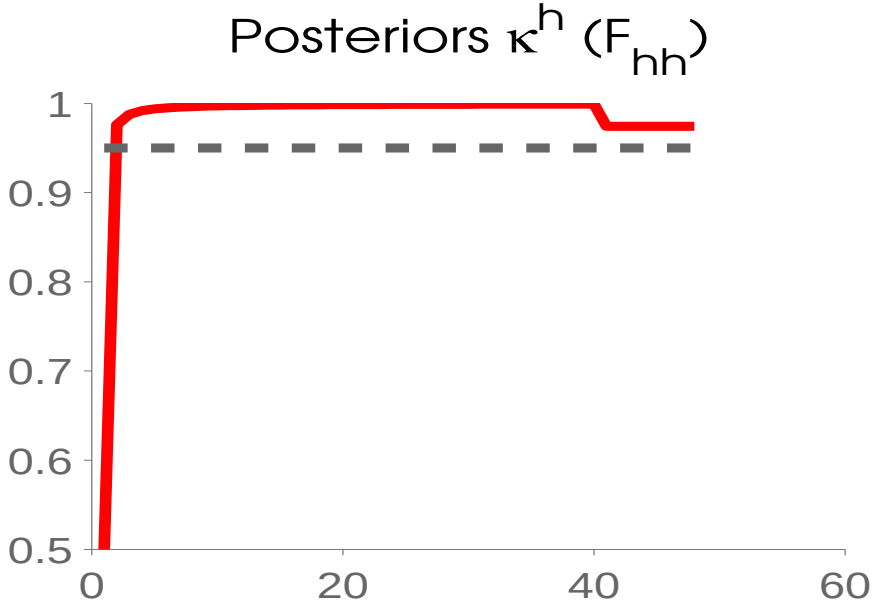


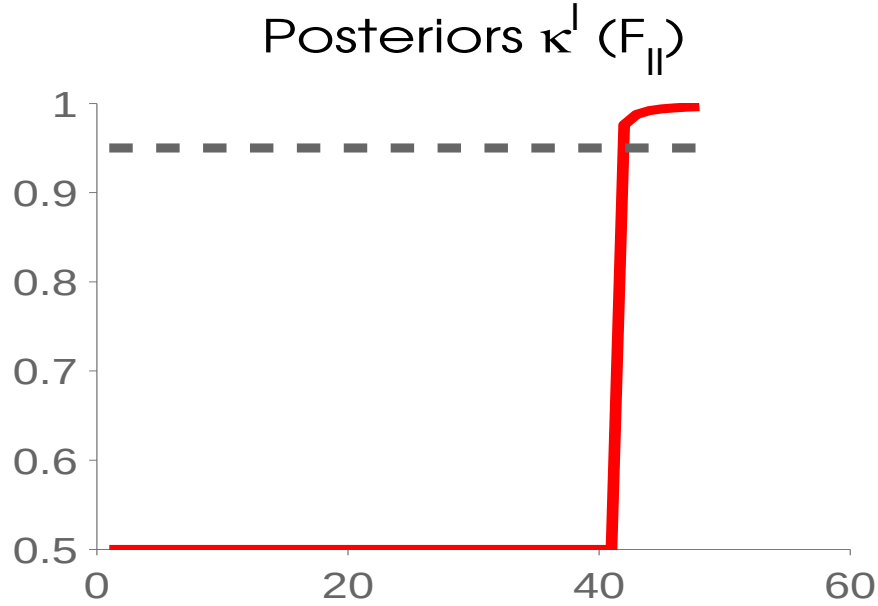


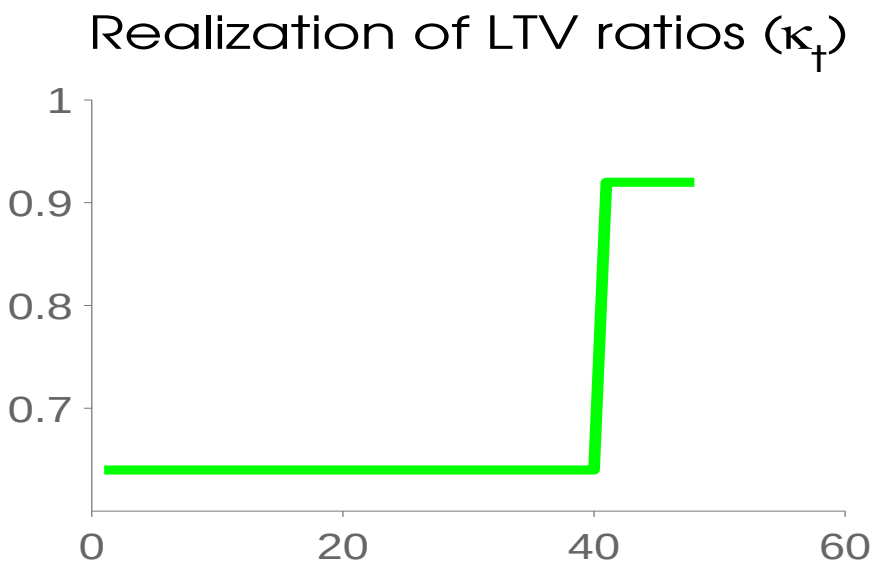


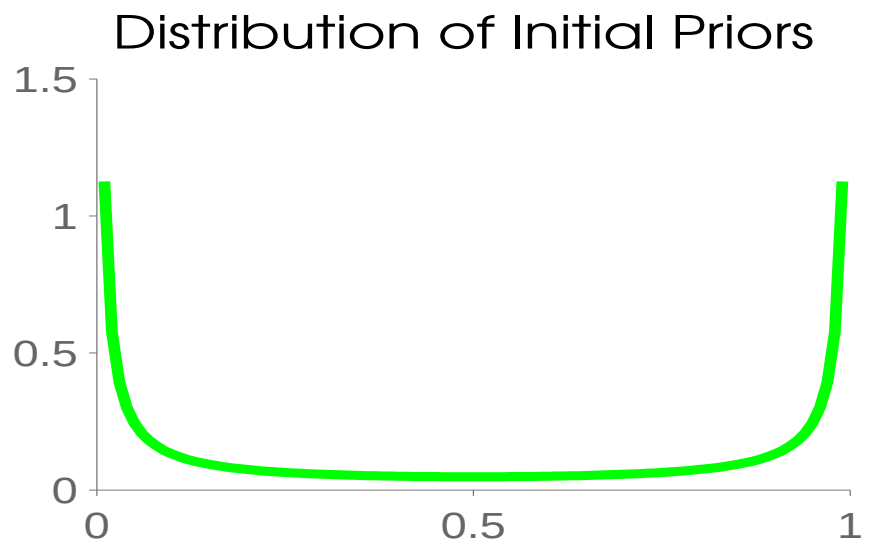


Evolution of Posteriors in Baseline



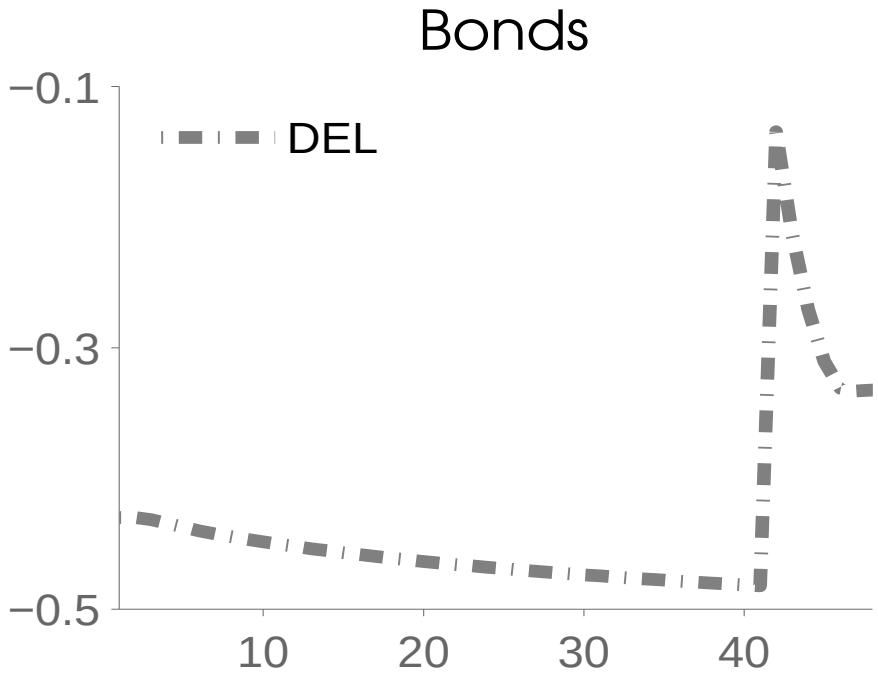


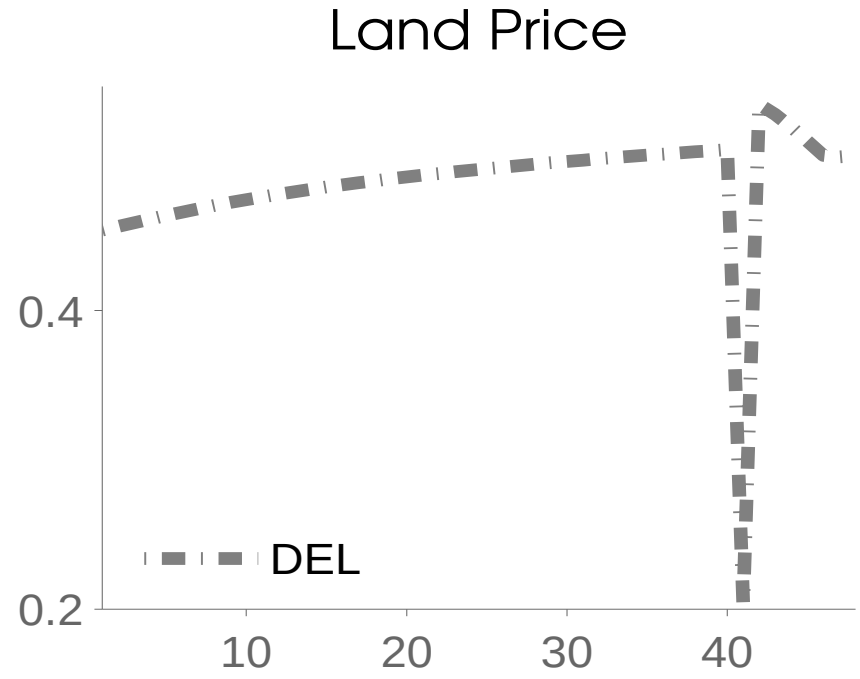


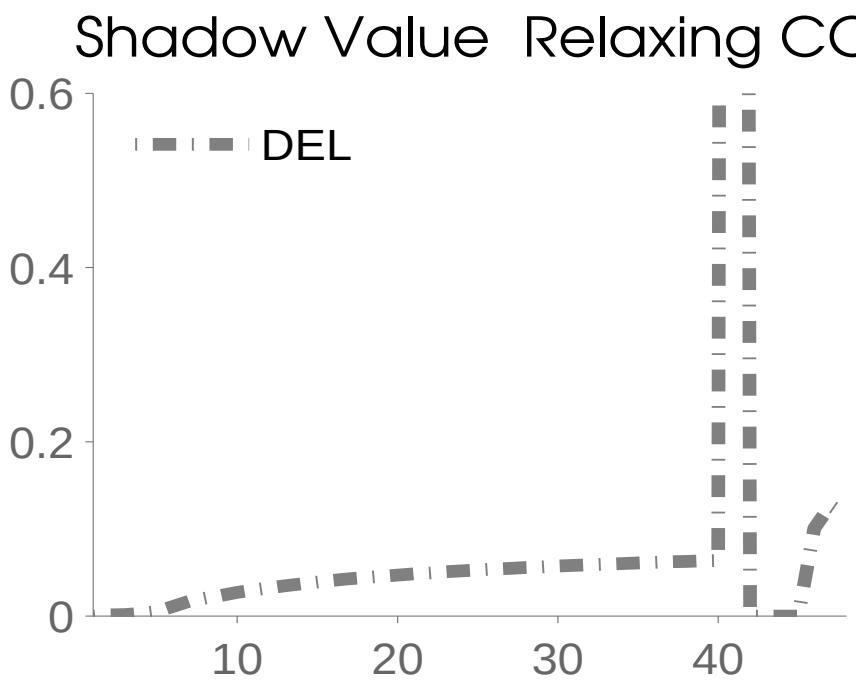


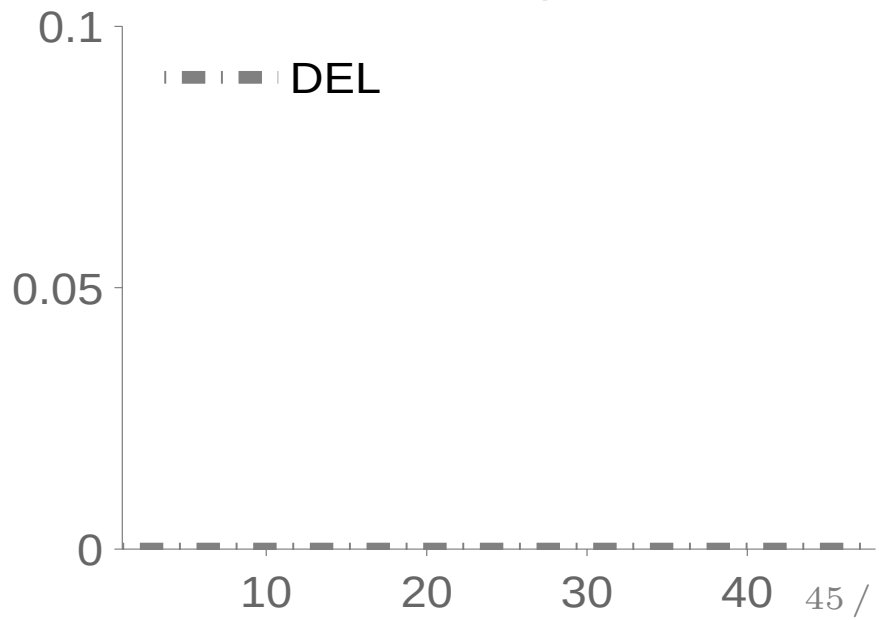
Findings in Gradual Optimism Scenario

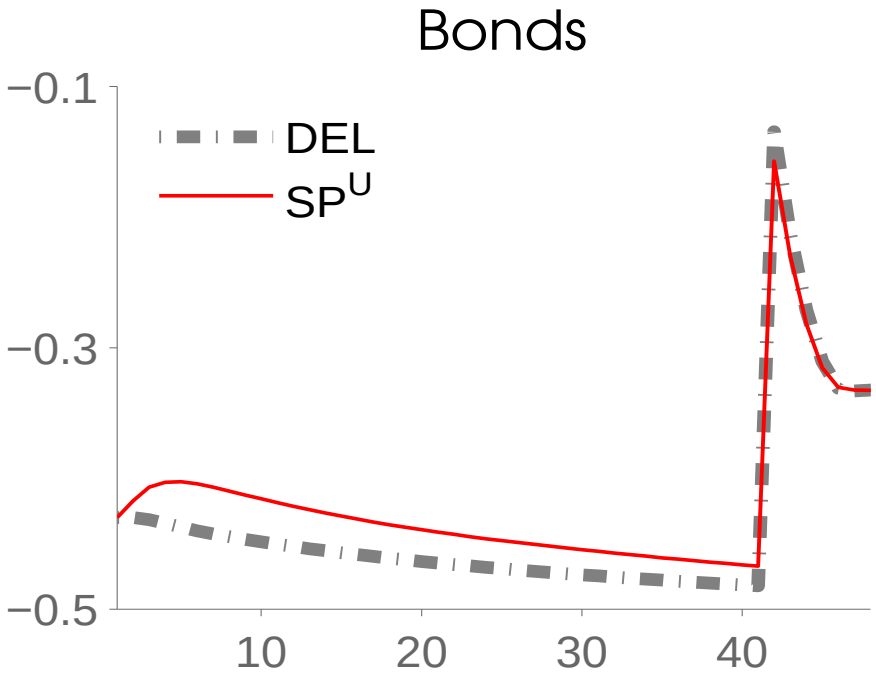
- Now, **uninformed planner** reduces debt levels up to 4 percentage points of GDP and reduces fall in asset prices by 17%
- Similar findings for decentralized equilibrium and informed planner

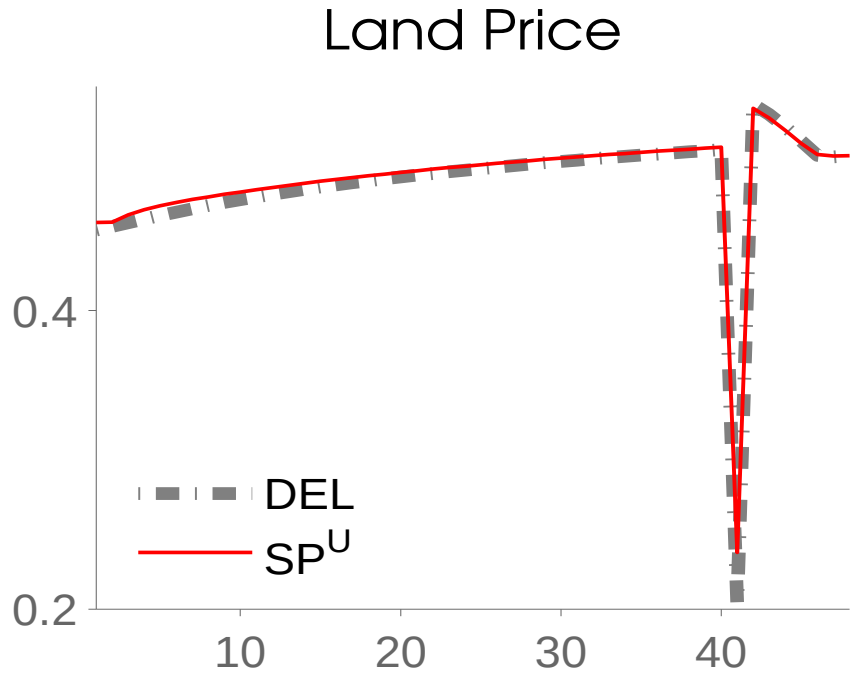

Bonds
−0.1
−0.3
−0.5
DEL
10
20
30
40

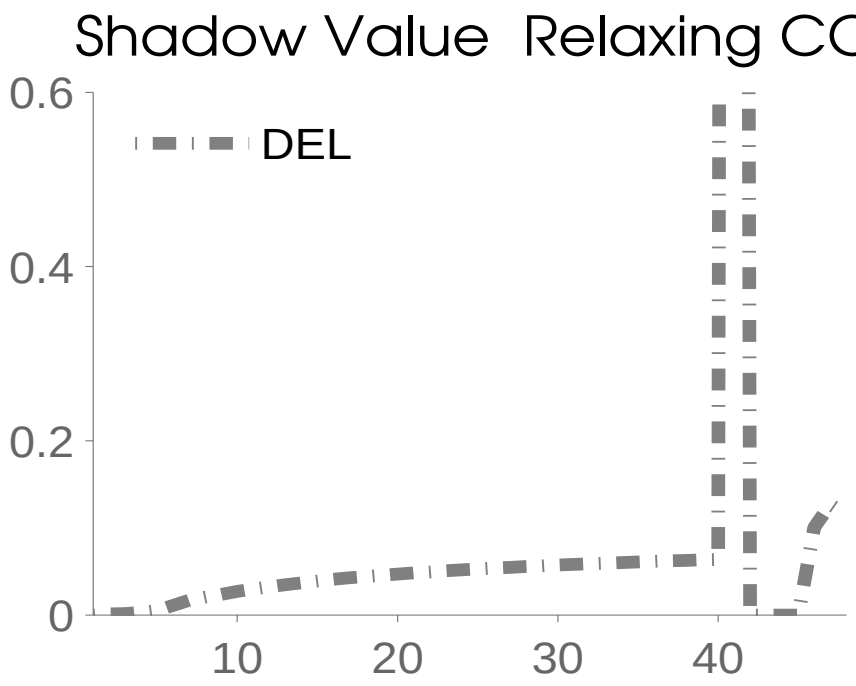

Land Price
0.4
0.2
DEL
10
20
30
40


Shadow Value Relaxing CC
0.6
0.4
0.2
0
DEL
10
20
30
40


Externality Term
0.1
0.05
0
DEL
10
20
30
40


Bonds
−0.1
−0.3
−0.5
DEL
SP^U
10
20
30
40


Land Price
0.4
0.2
DEL
SP^U
10
20
30
40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0.2
0
DEL
10
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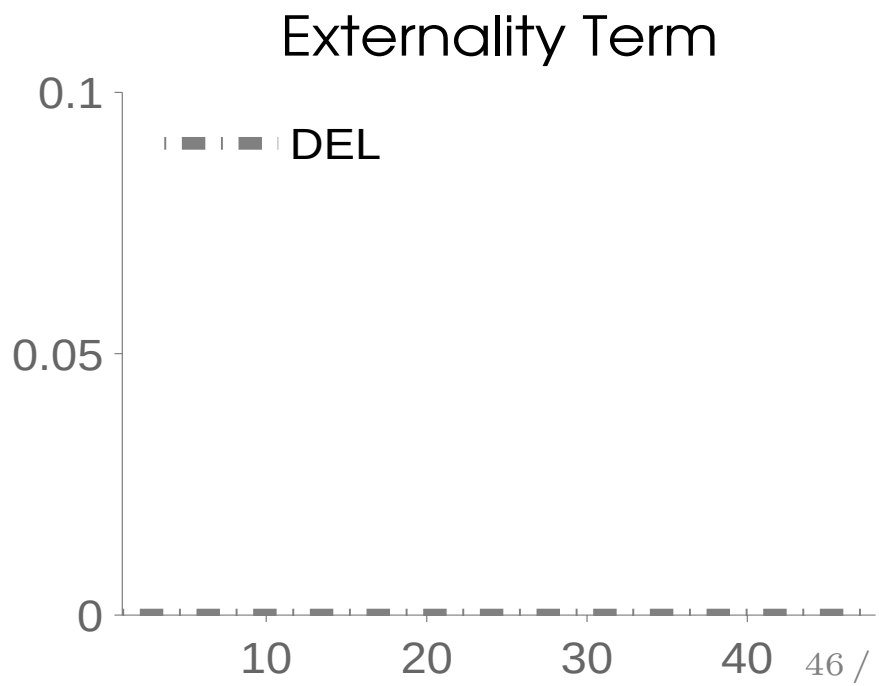
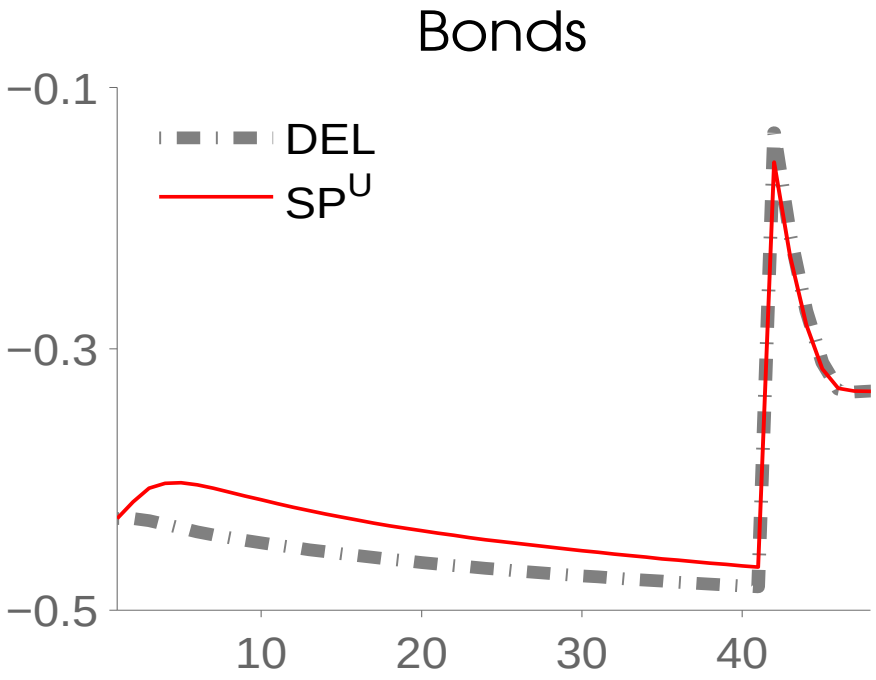
30
40


Externality Term
0.1
0.05
0
DEL
10
20
30
40


Bonds
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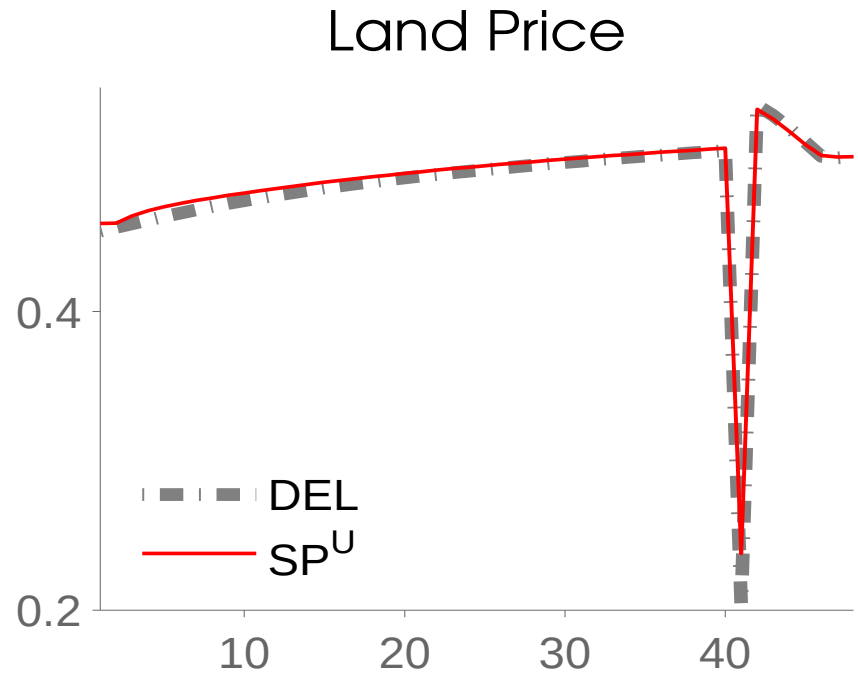
−0.3
−0.5
DEL
SP^U
10
20
30
40


Land Price
0.4
0.2
DEL
SP^U
10
20
30
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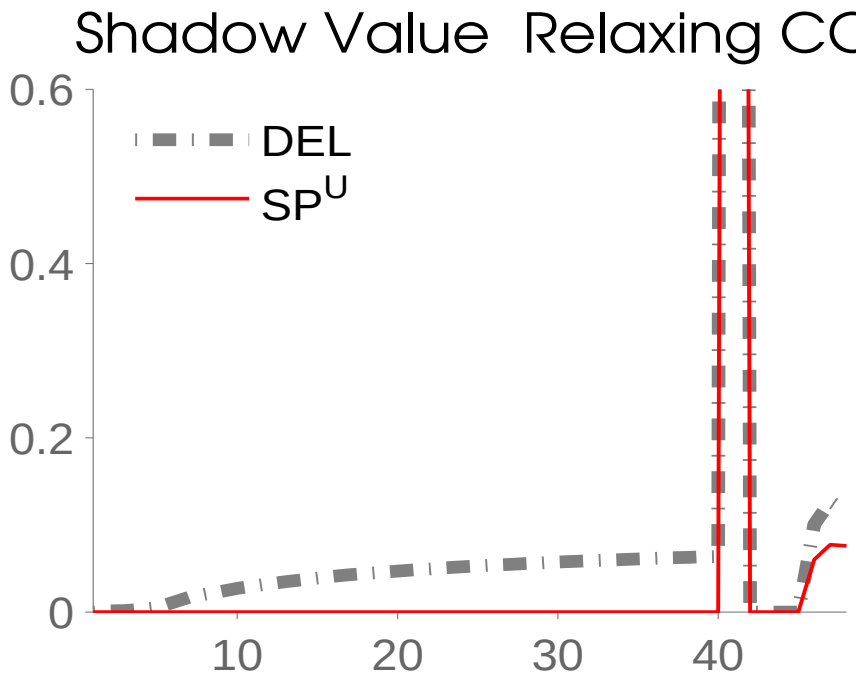
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SP^U
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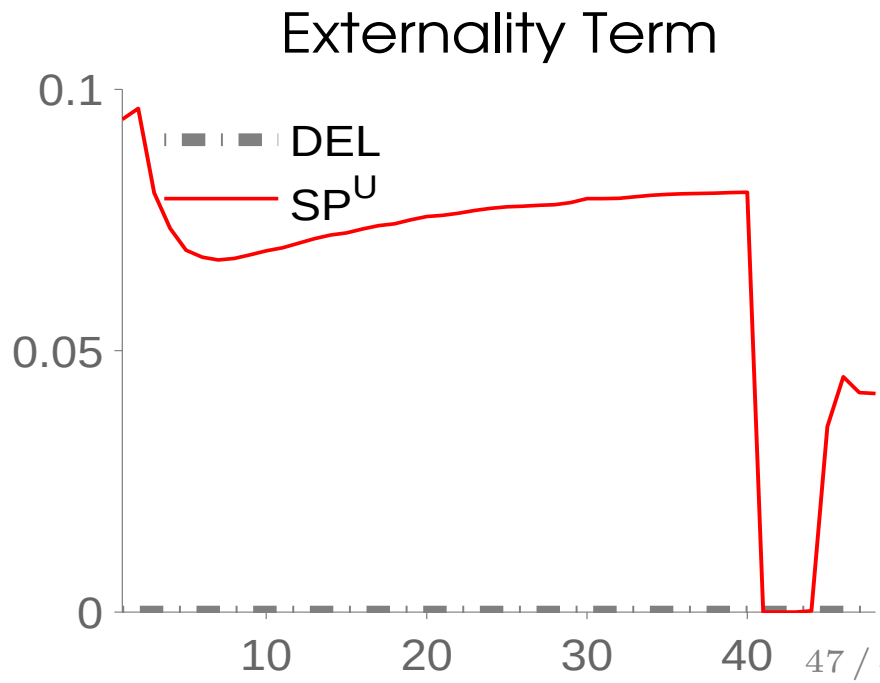
Externality Term
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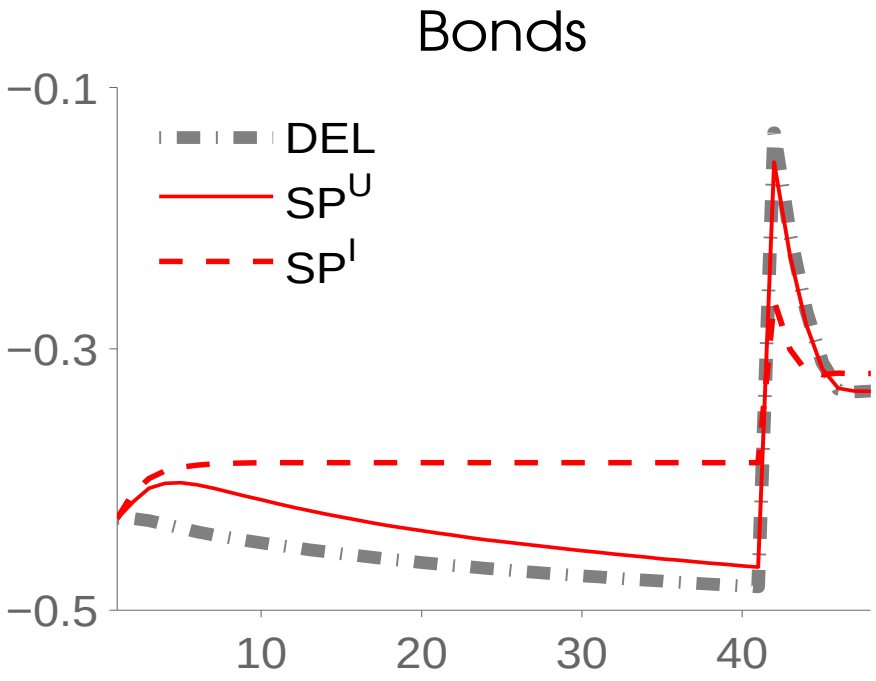
Bonds
−0.1
−0.3
−0.5
DEL
SP^U
SP^I
10
20
30
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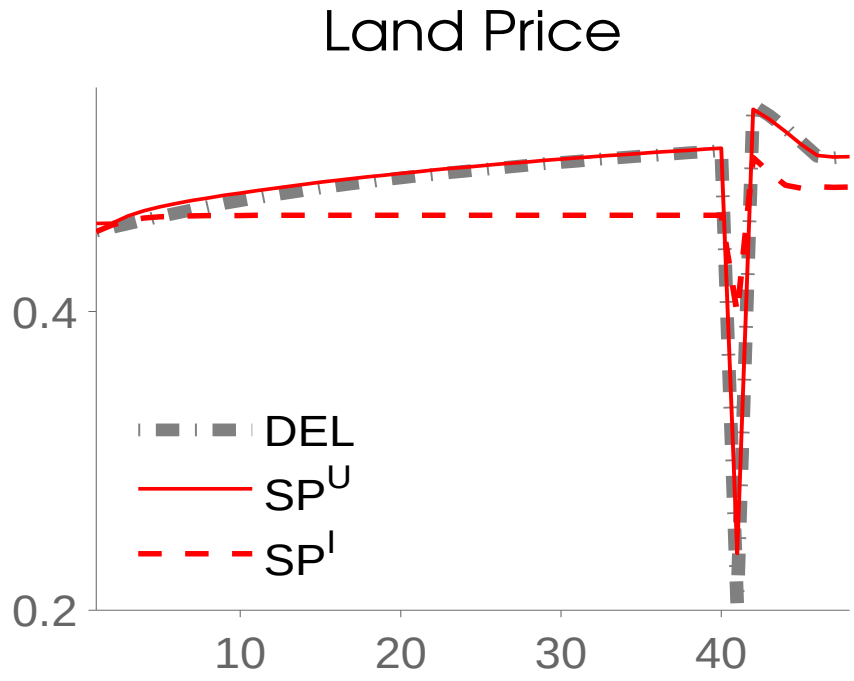
Land Price
0.4
0.2
DEL
SP^U
SP^I
10
20
30
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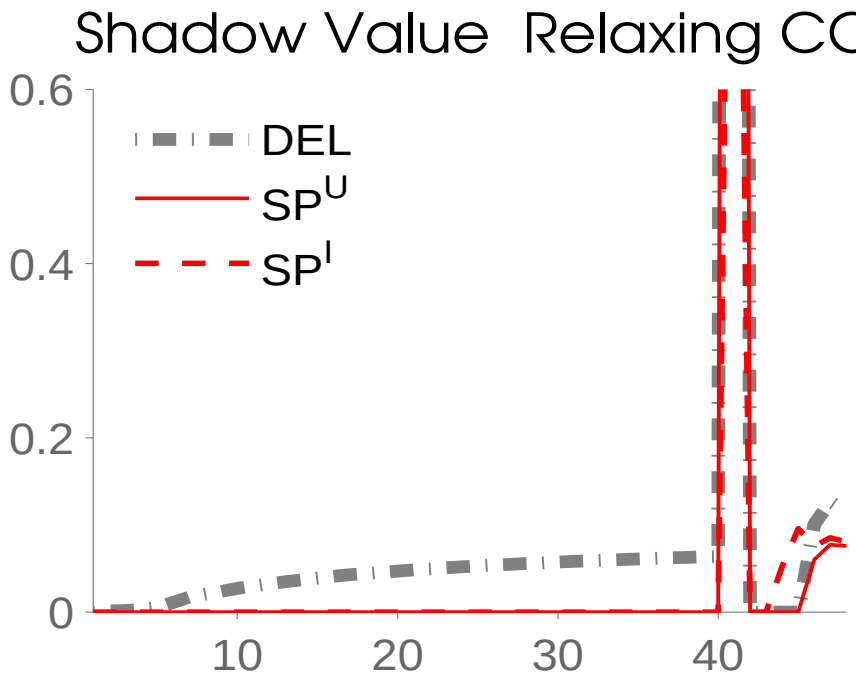
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SP^I
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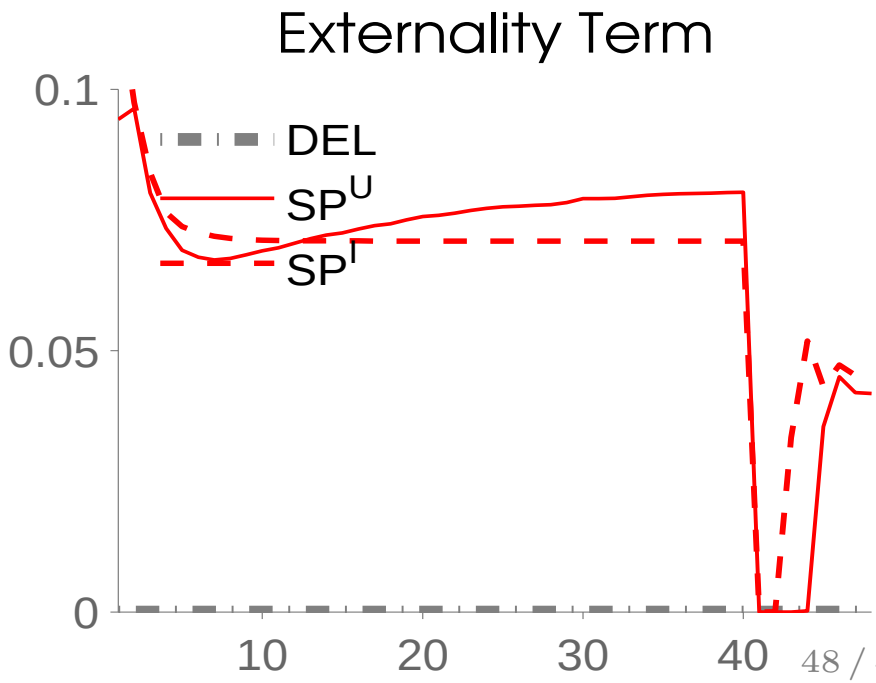
Externality Term
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0.05
0
DEL
SP^U
SP^I
10
20
30
40

Conclusion

- Analyze role of macro-prudential policy in a Neo-Fisherian model with credit cycles driven by interaction of credit frictions & beliefs about riskiness of new financial regime
- Financial innovation and beliefs about the stability of new financial regimes play important role in the design of macroprudential policy
- Incorporating uncertainty about financial environment and heterogeneity in beliefs is only one of many challenges ahead