Fisherian Models of Financial Crises and Macroprudential Policy

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Layout of the Lectures

1. Stylized facts of credit booms & Sudden Stops
2. Basics of nonlinear financial crises models
3. Analytical foundations of Fisherian models (debt-deflation mechanism and pecuniary externalities)
4. Quantitative applications: (a) Foreign reserves as insurance, (b) Explaining Sudden Stops facts
5. Macroprudential policy analysis
   - DTI models with nontradables (news shocks & global liquidity)
   - LTV models with assets/housing as collateral
   - LTV models with financial innovation and learning
   - Implementation hurdles and costly tradeoffs

Related literature

- Empirical studies of credit booms, fin. cycles: Borio (95), (12), Schularick & Taylor (12), Coimbra & Rey (18), Hartwig et. al. (21), Mendoza & Terrones (10,12), Mian & Safi (18)
- Theoretical work on financial amplification: Fisher (33), Minsky (92), Bernanke and Gertler (89), Kiyotaki & Moore (97), Calvo (98), Aiyagari & Gertler (99), Lorenzoni (08), Geanakoplos (09),…
- Quantitative nonlinear models of fin. crises:
  1. **DTI models with debt in tradables backed by nont. income**: Mendoza (02), Durdu et al. (08), Benigno et al. (11), Bianchi (11), Hernandez & Mendoza (17), Mendoza & Rojas (19), Schmitt-Grohe & Uribe (18),…
  2. **LTV models with international asset trading**: Mendoza & Smith (06,14), Durdu & Mendoza (06), Mendoza & Quadrini (10),…
  3. **LTV models of business cycles and financial crises**: Jermann & Quadrini (12), Mendoza (10), Brunnermeier & Sanikov (14), Schmitt-Grohe & Uribe (17),…

Stylized Facts of Sudden Stops and Credit Booms

Credit Boom Events in Macro and Micro Data (Mendoza & Terrones 2010, 2012)

Identifying credit booms

- A "boom" is defined as a **sharp** increase from a **normal** situation.
- Country *i* is in a credit boom at date *t* if:

$$l_{i,t} \geq \phi \sigma (l_i)$$

ϕ :	boom threshold factor
l_{it} :	deviation from HP trend in log real credit per capita
$\sigma(l_i)$:	standard deviation of $l_{it.}$

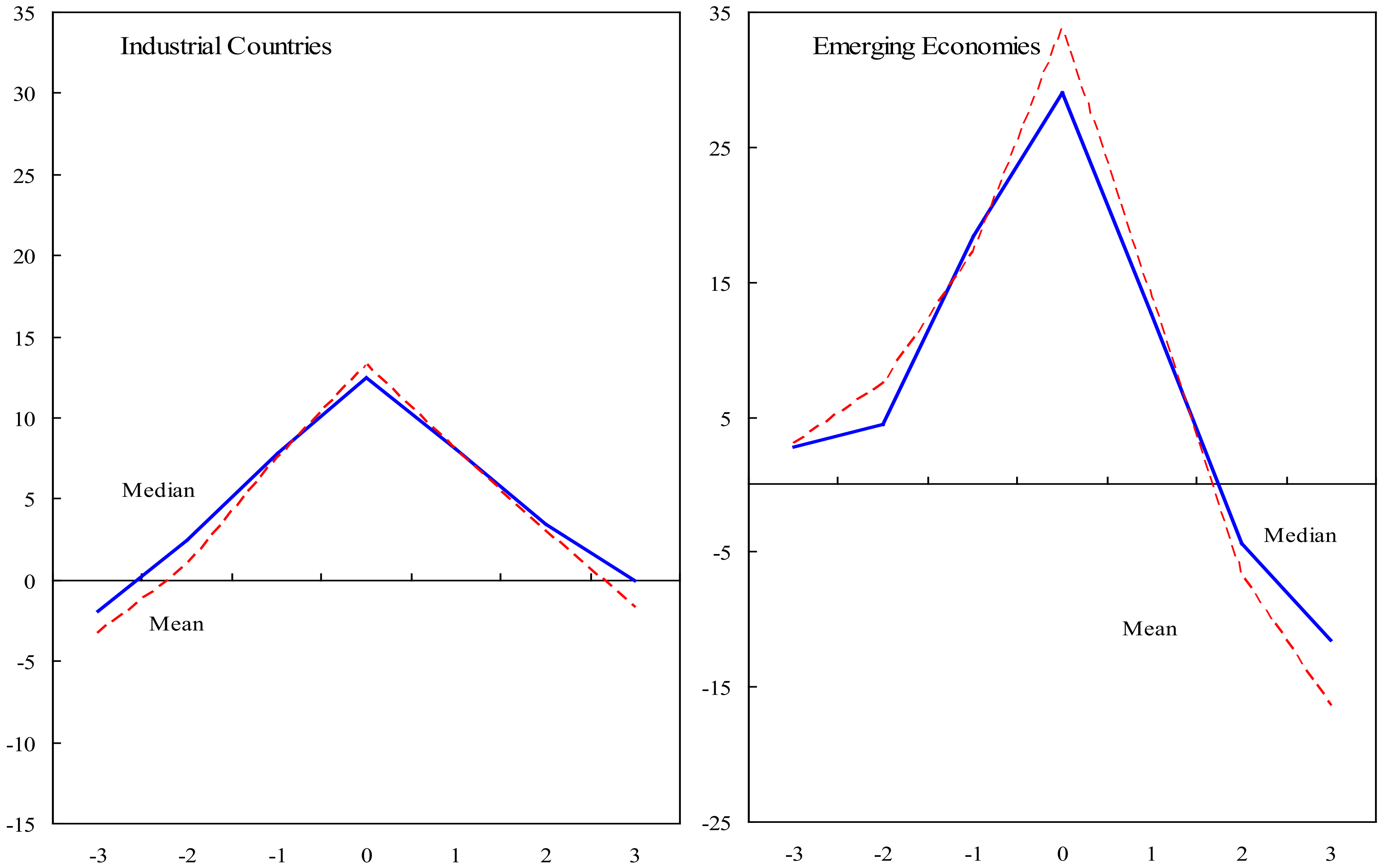
- Percentile identification criterion: Largest 5% of credit expansions in a country's distribution of cyclical component of real credit per capita
  - Excludes "regular" credit cycle (95% of credit fluctuations)
  - Excludes growth and transitional dynamics frequencies
  - Does not impose common trend in credit and output
  - Allows for country heterogeneity
  - Ex-post indicator (two-sided filter)

Main findings

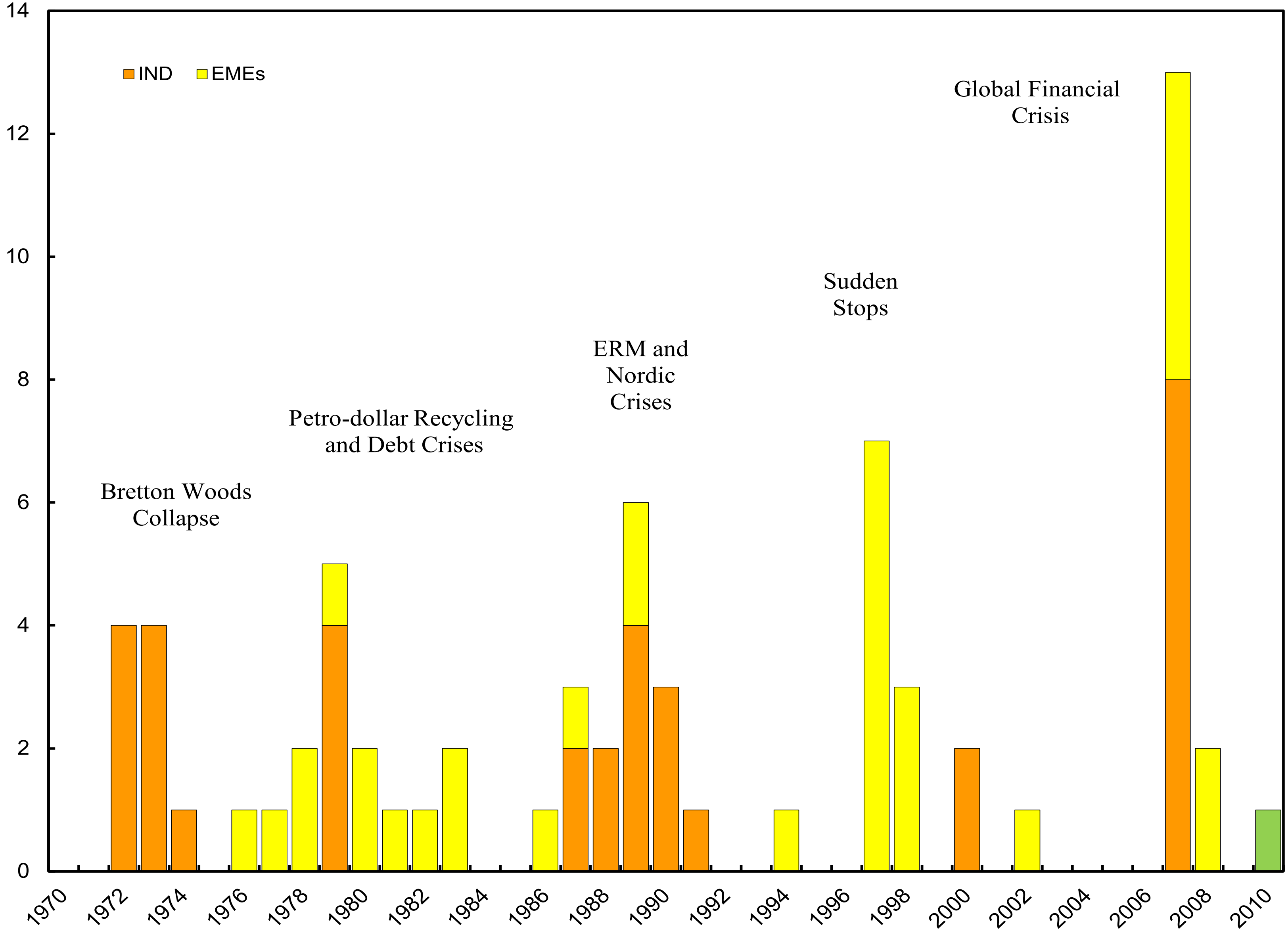
1. 70 events in data for 61 ICs and EMs, 1960-2010
2. Credit booms are infrequent (35in ICs & in EMs, 2.8% freq.)
3. Clustered around "big events" (e.g. ERM collapse, 2008 crash)
4. Strong association with business cycles & asset prices (in EMs also with RER and nontradables sector)
5. Consistent with firm & bank level dynamics
6. Similar duration (5-6 yrs) and size (2.1 std. deviations)
7. 1/3rd of credit booms end in banking or currency crises, 1/4th end in Sudden Stops
8. 1/4th to 1/3rd preceded by financial innovation (financial reforms or surges in capital inflows), and 2/3rds occur with managed ex. rates

Credit booms: seven-year event windows

(Cross-country means and medians of cyclical component of credit)

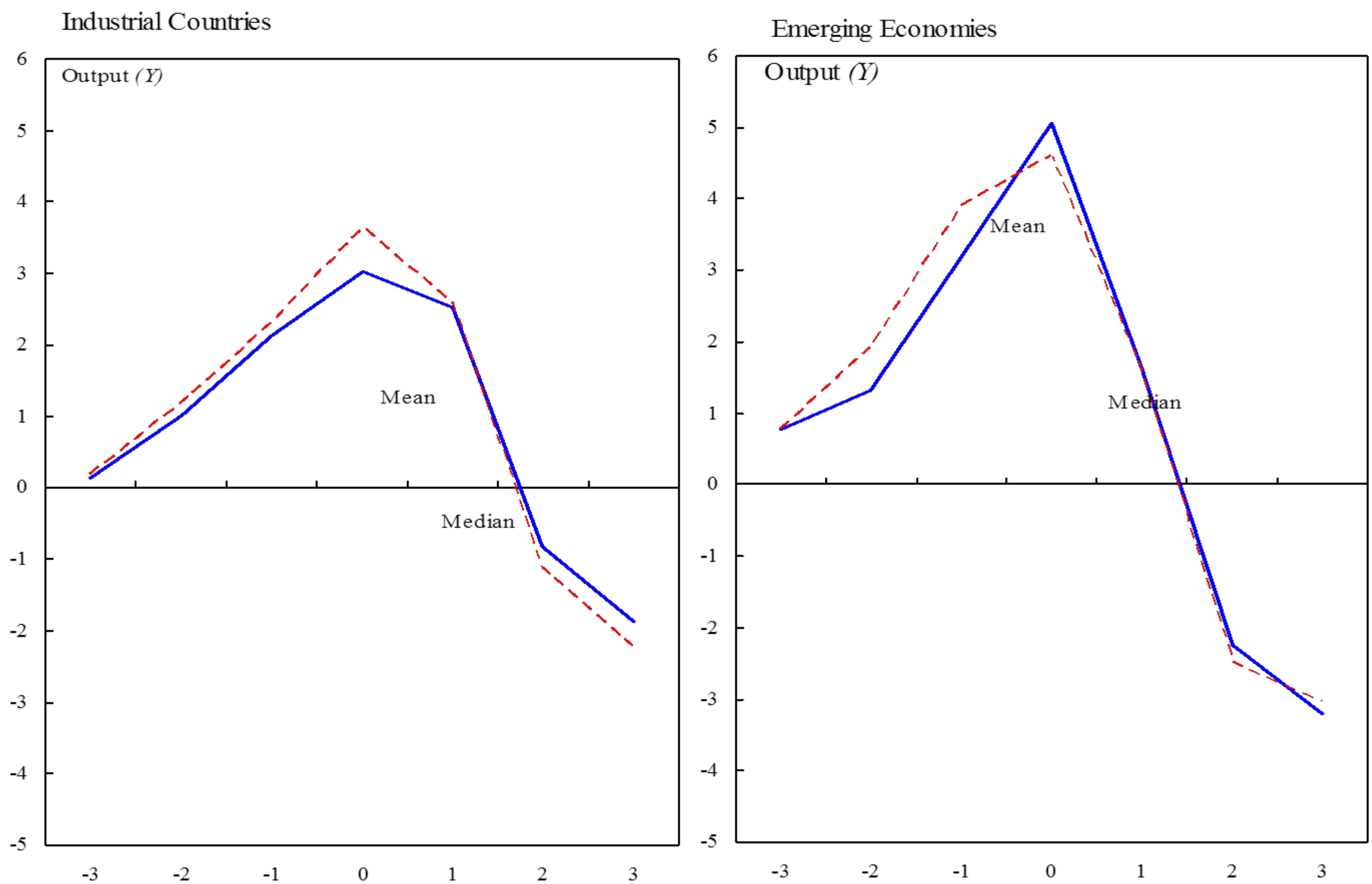


CBs are synchronized around "big events"



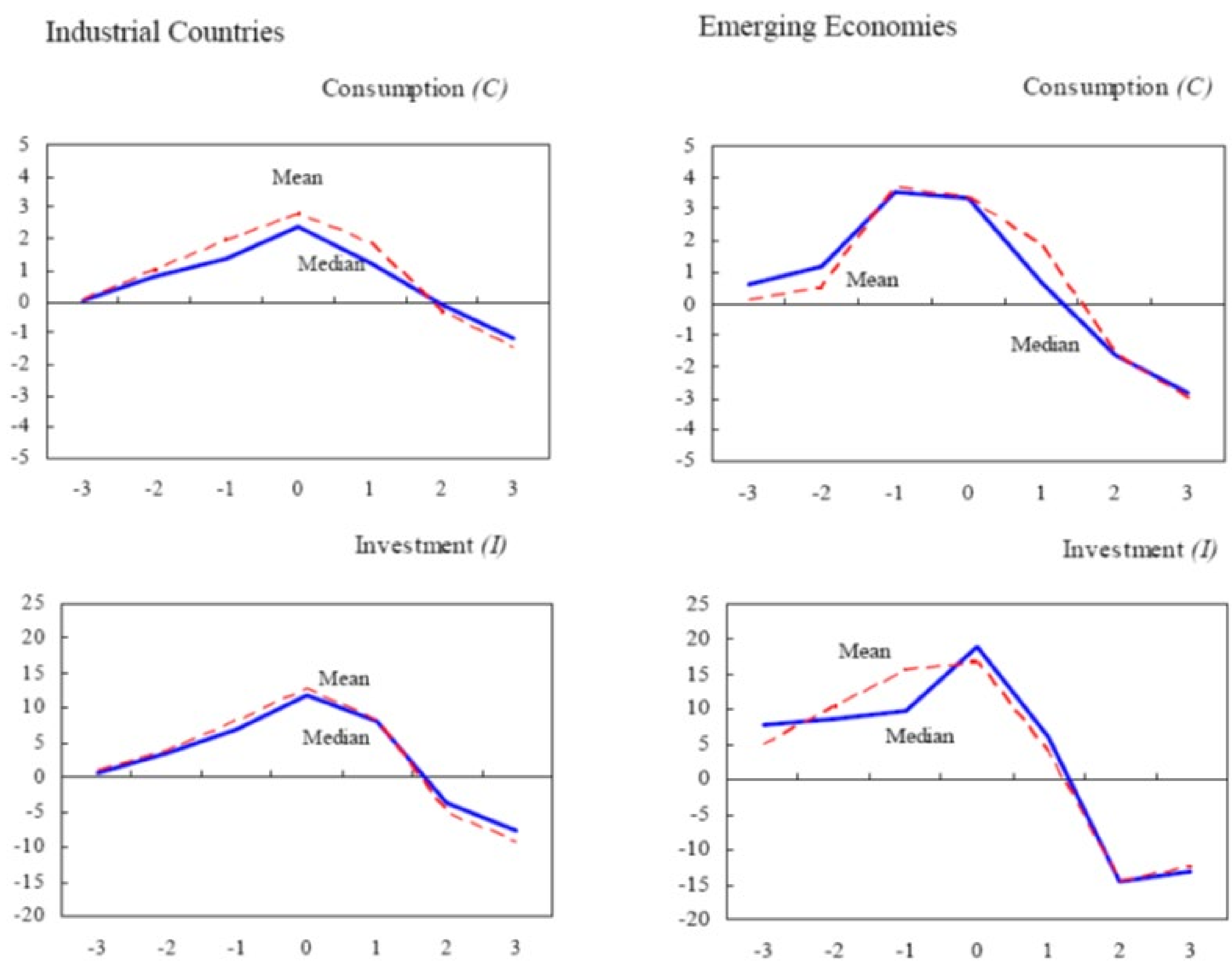
Output during credit booms

(Cross-country means and medians of cyclical component of GDP)



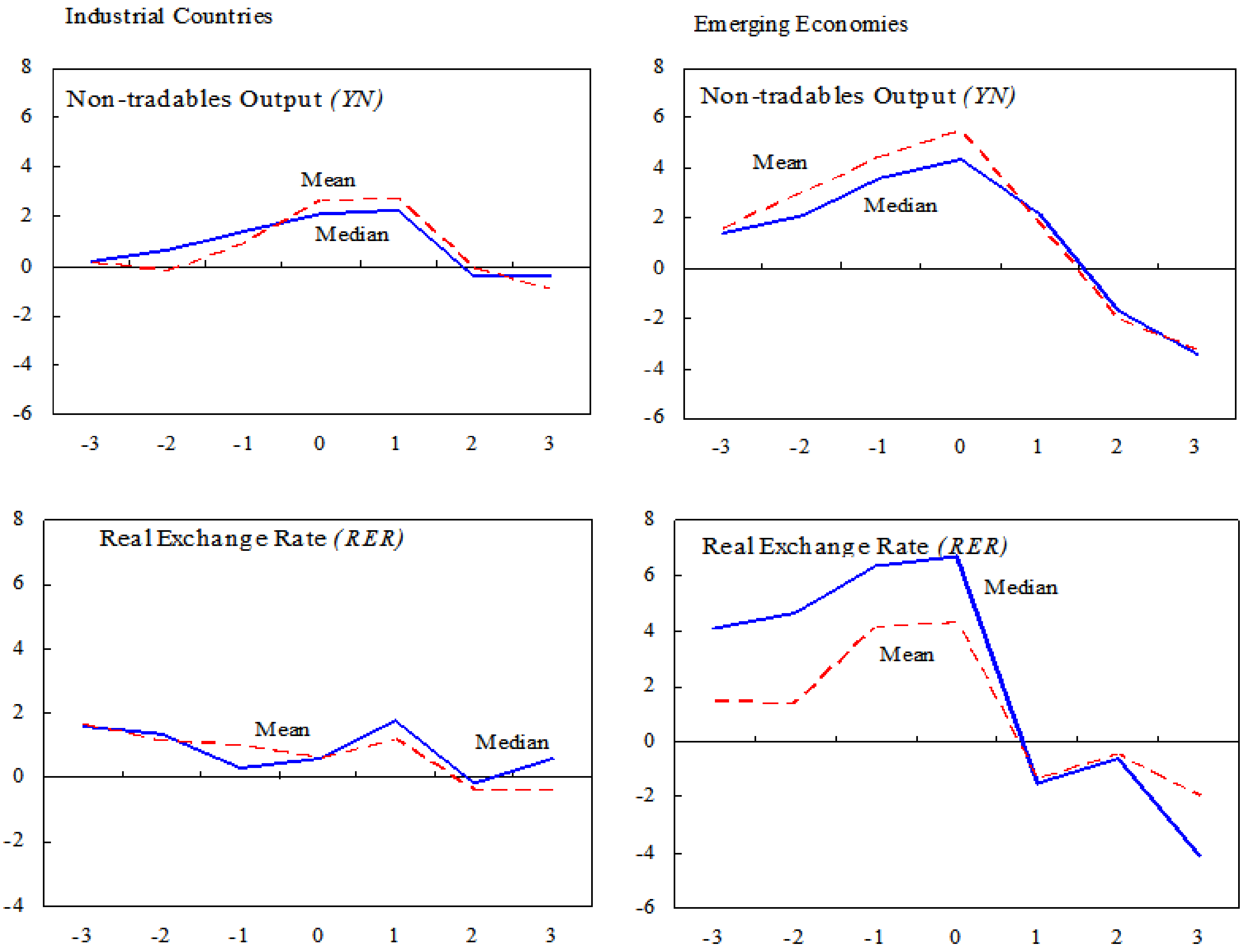
Consumption & investment during credit booms

(Cross-country means and medians of cyclical component of GDP)



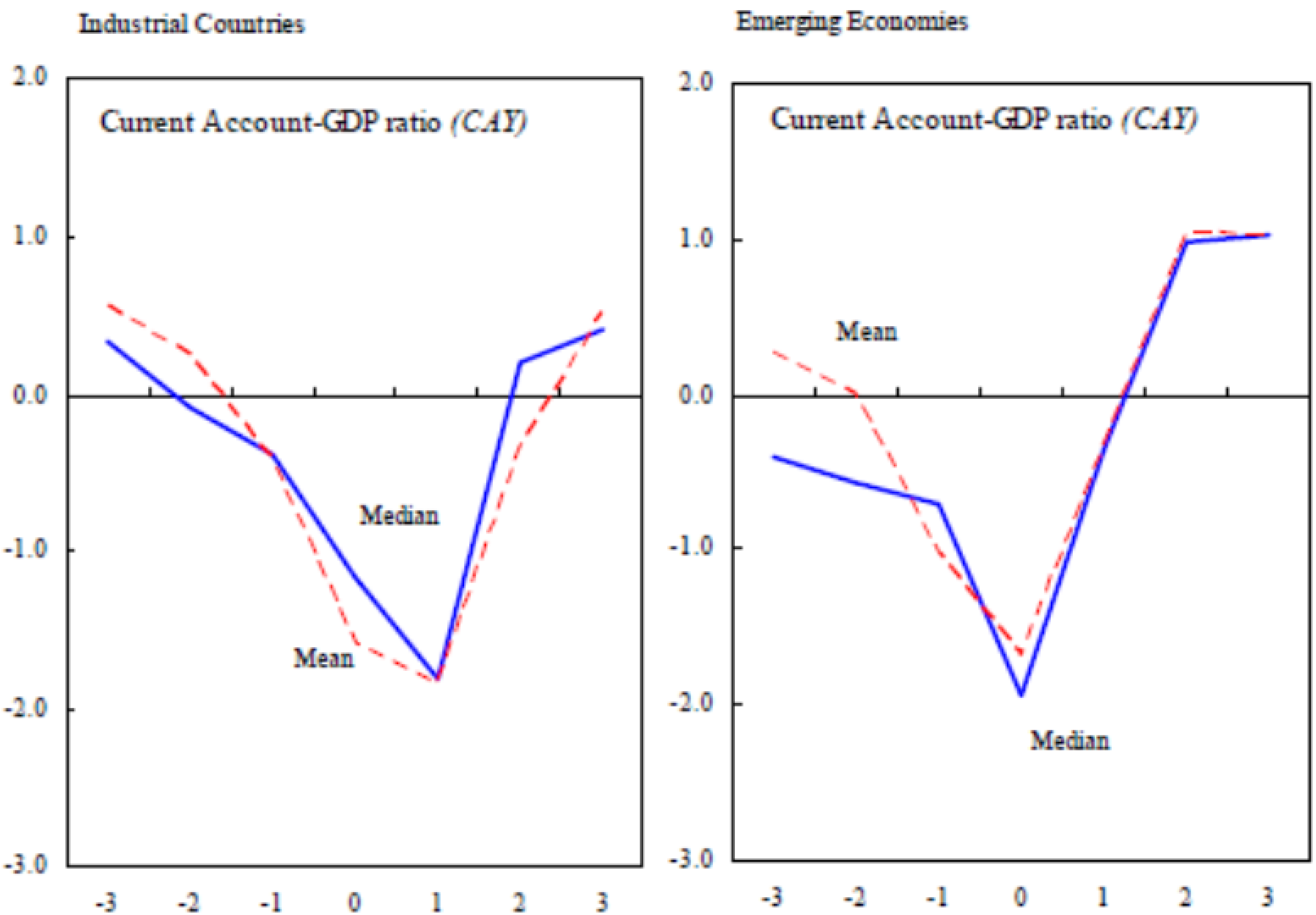
Nontradables GDP & real exchange rates

(Cross-country means and medians of cyclical component of GDP)



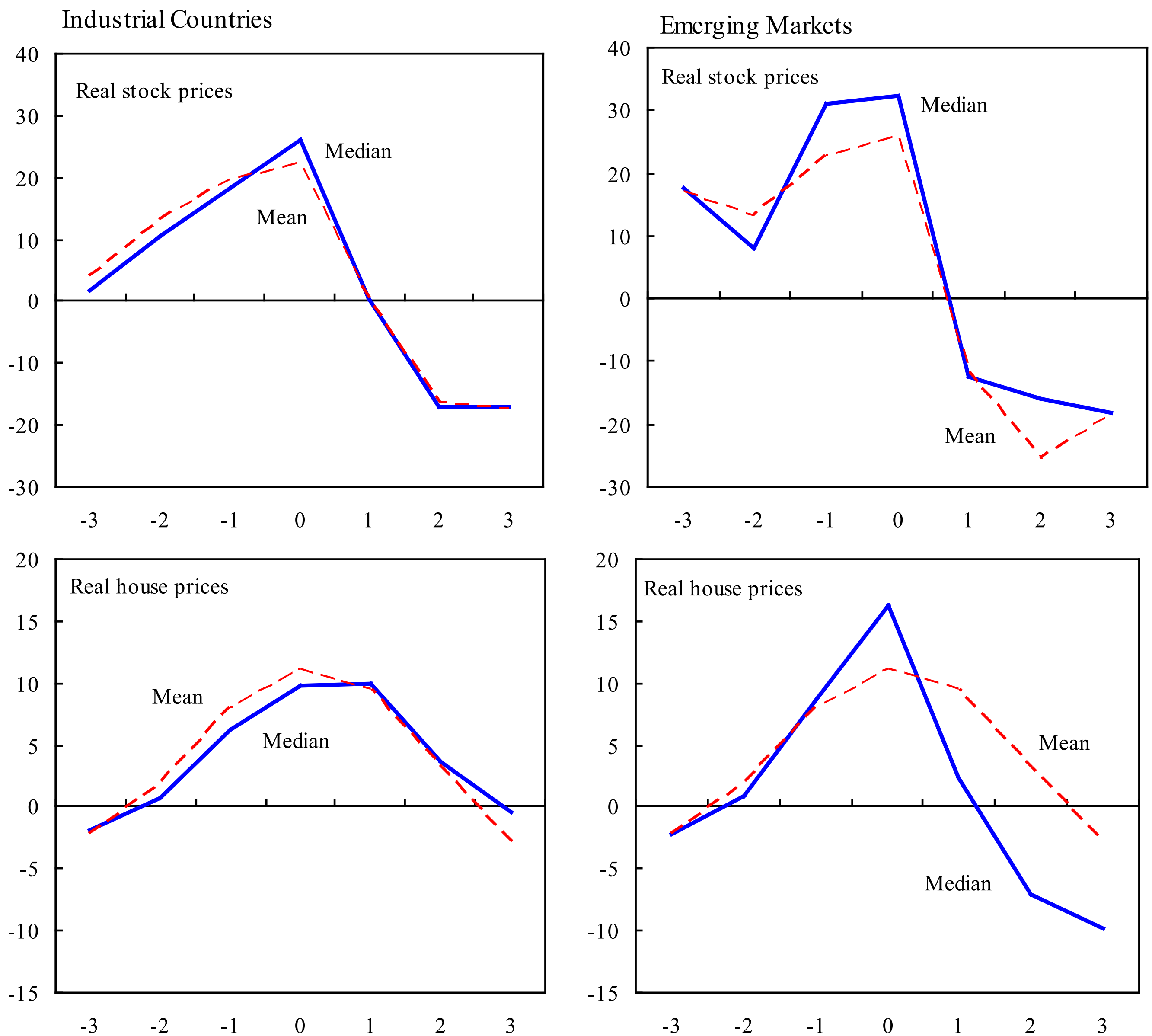
Current account during credit booms

(Cross-country means and medians of cyclical component of GDP)



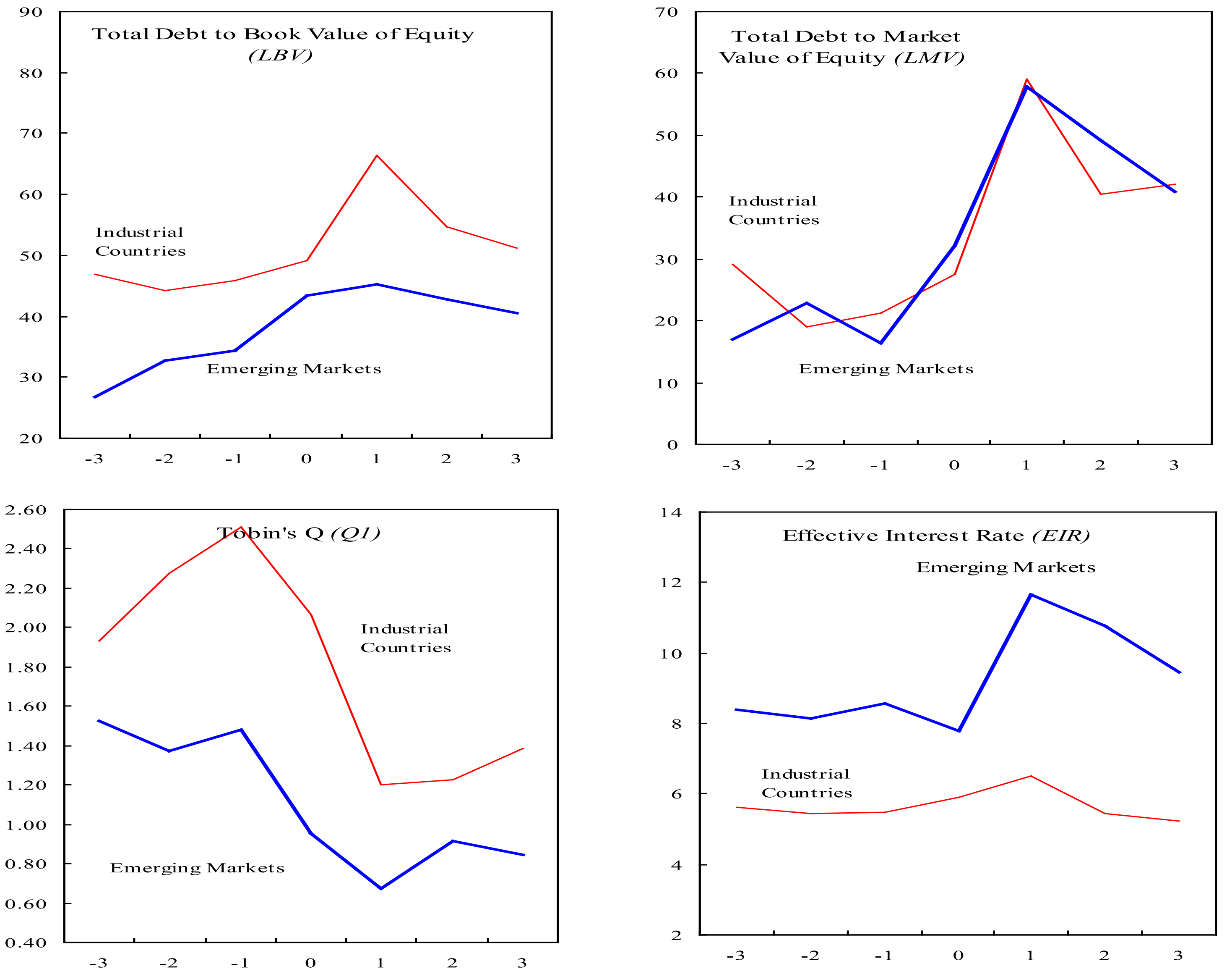
Asset prices during credit booms

(Cross-country means and medians of cyclical component)

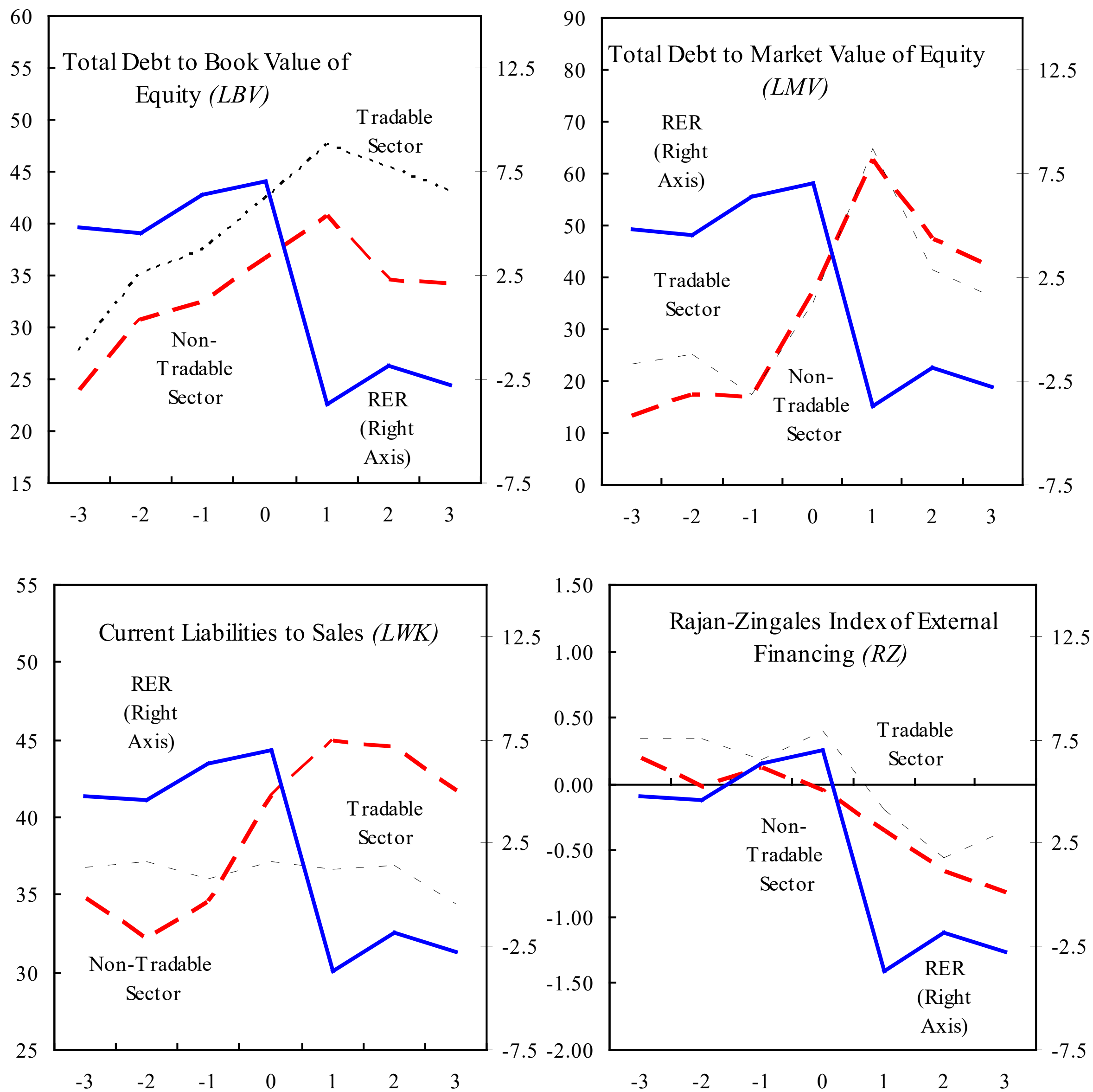


Corporate financial indicators during credit booms

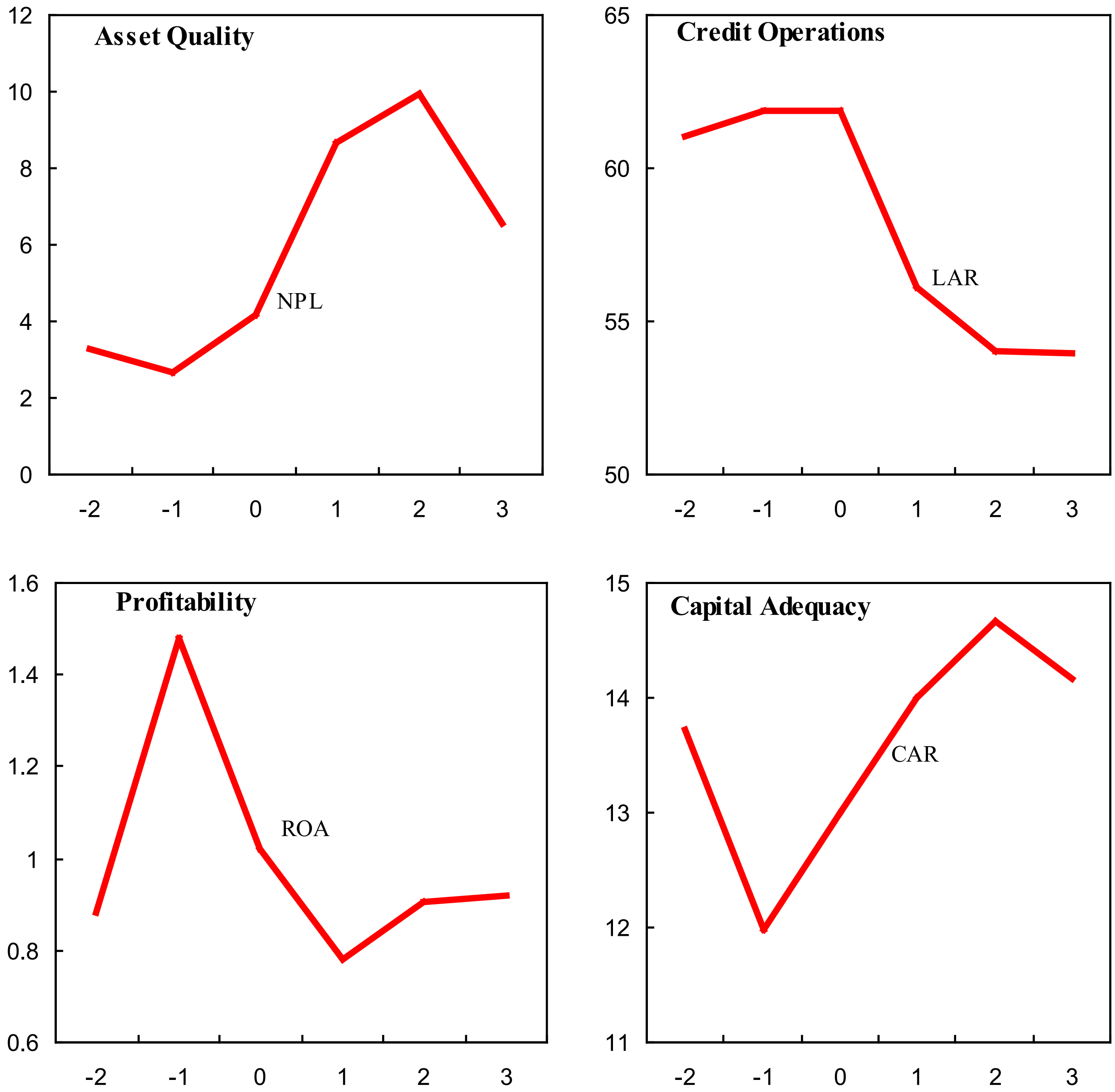
(firm-level medians averaged across countries)



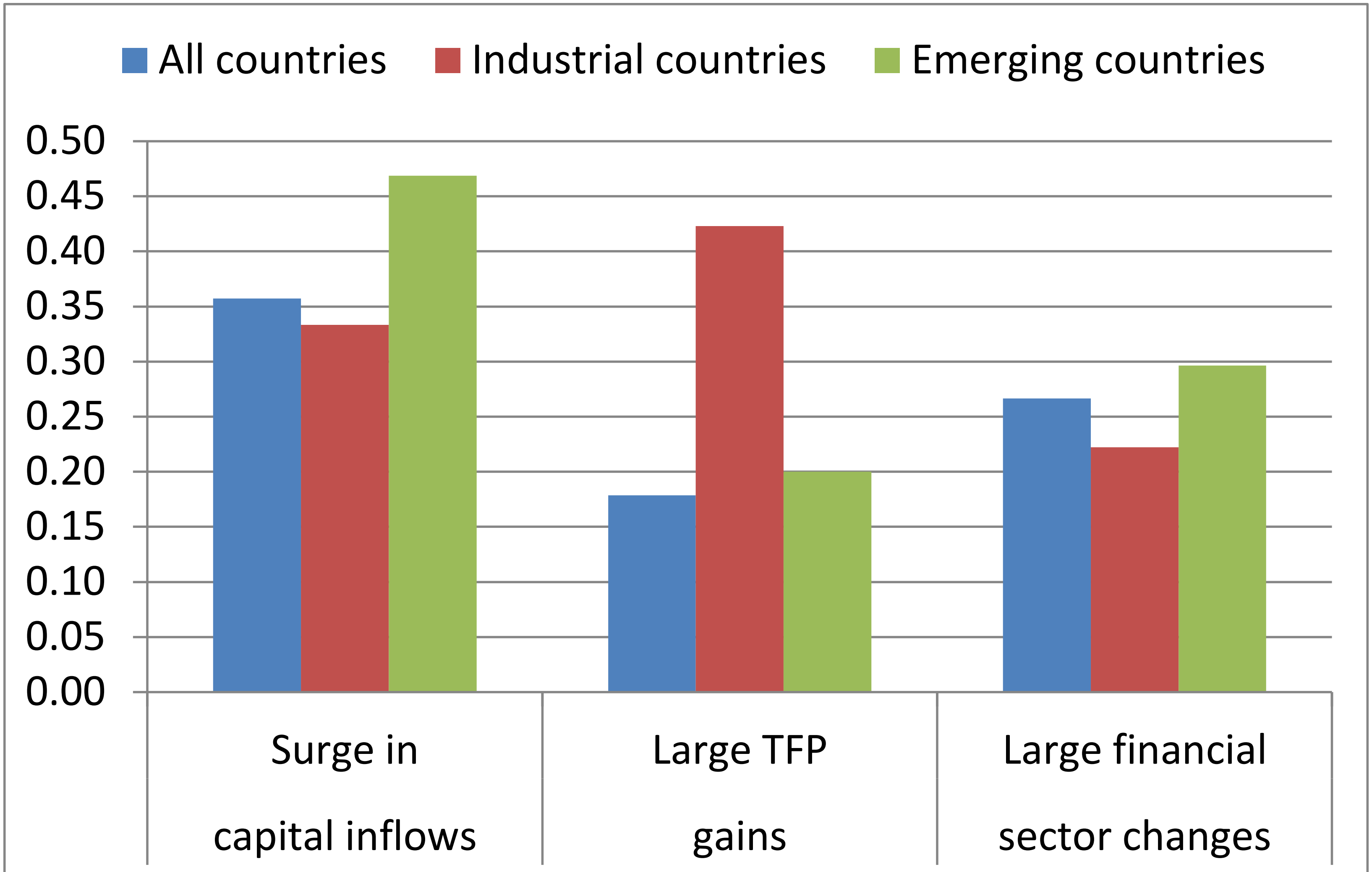
EM corporations: Tradables v. Nontradables



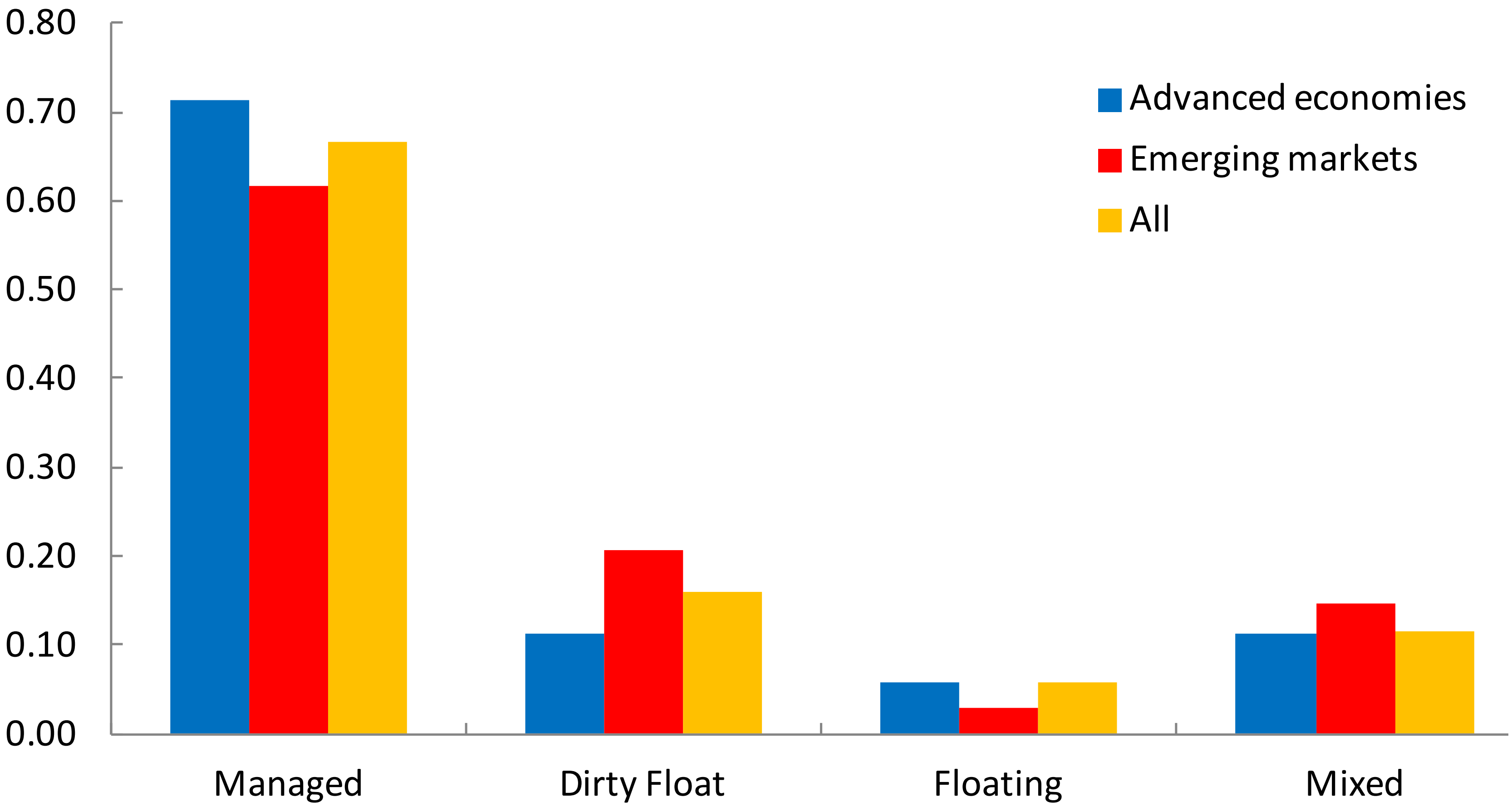
Bank-level indicators in EMs



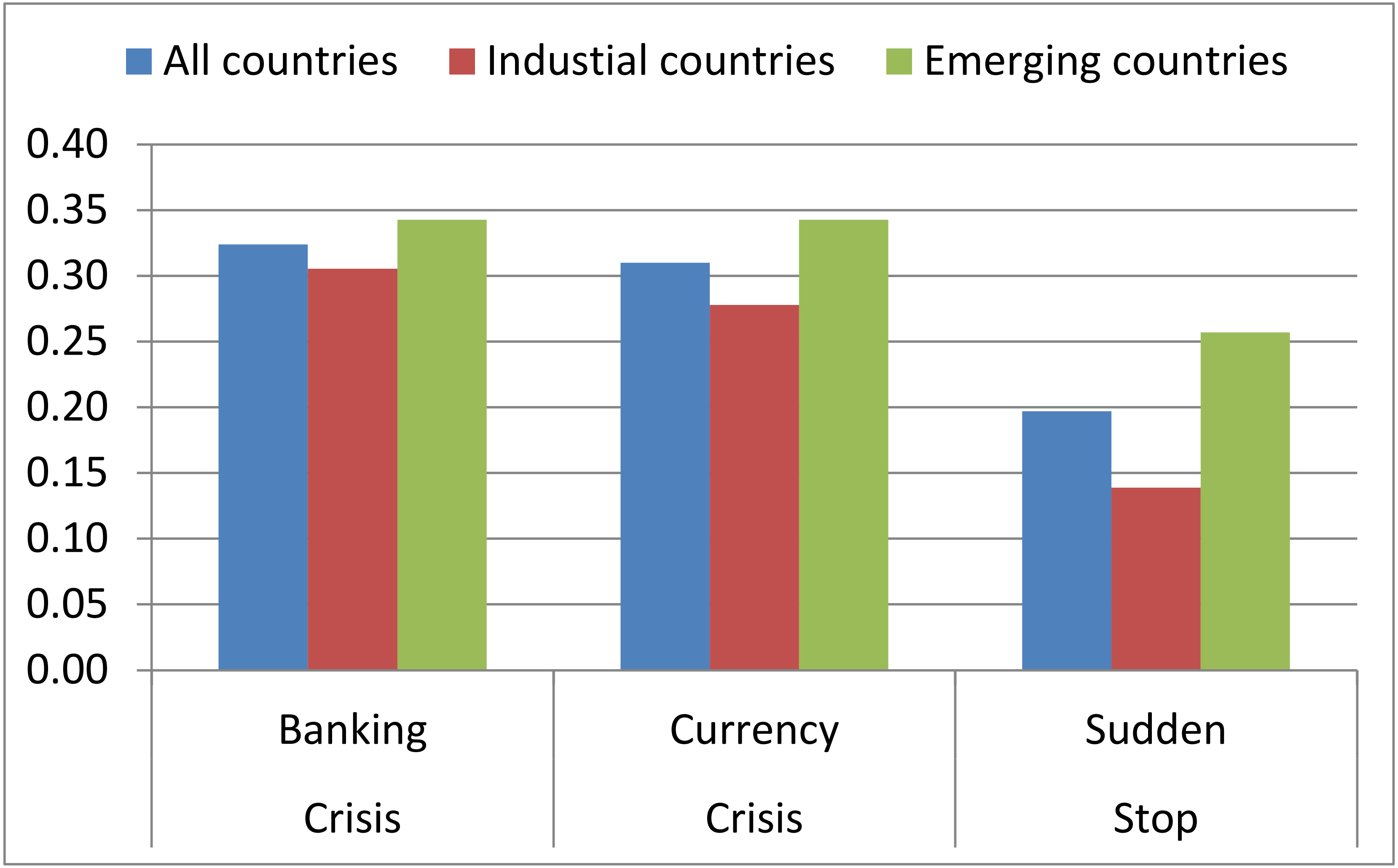
Credit booms and potential triggers
(frequency analysis)



Credit booms and exchange rate regimes
(frequency analysis)



Crises after credit boom peaks
(frequency analysis)



Sudden Stops:
Cross-Country Event Analysis
(Bianchi & Mendoza (2020))

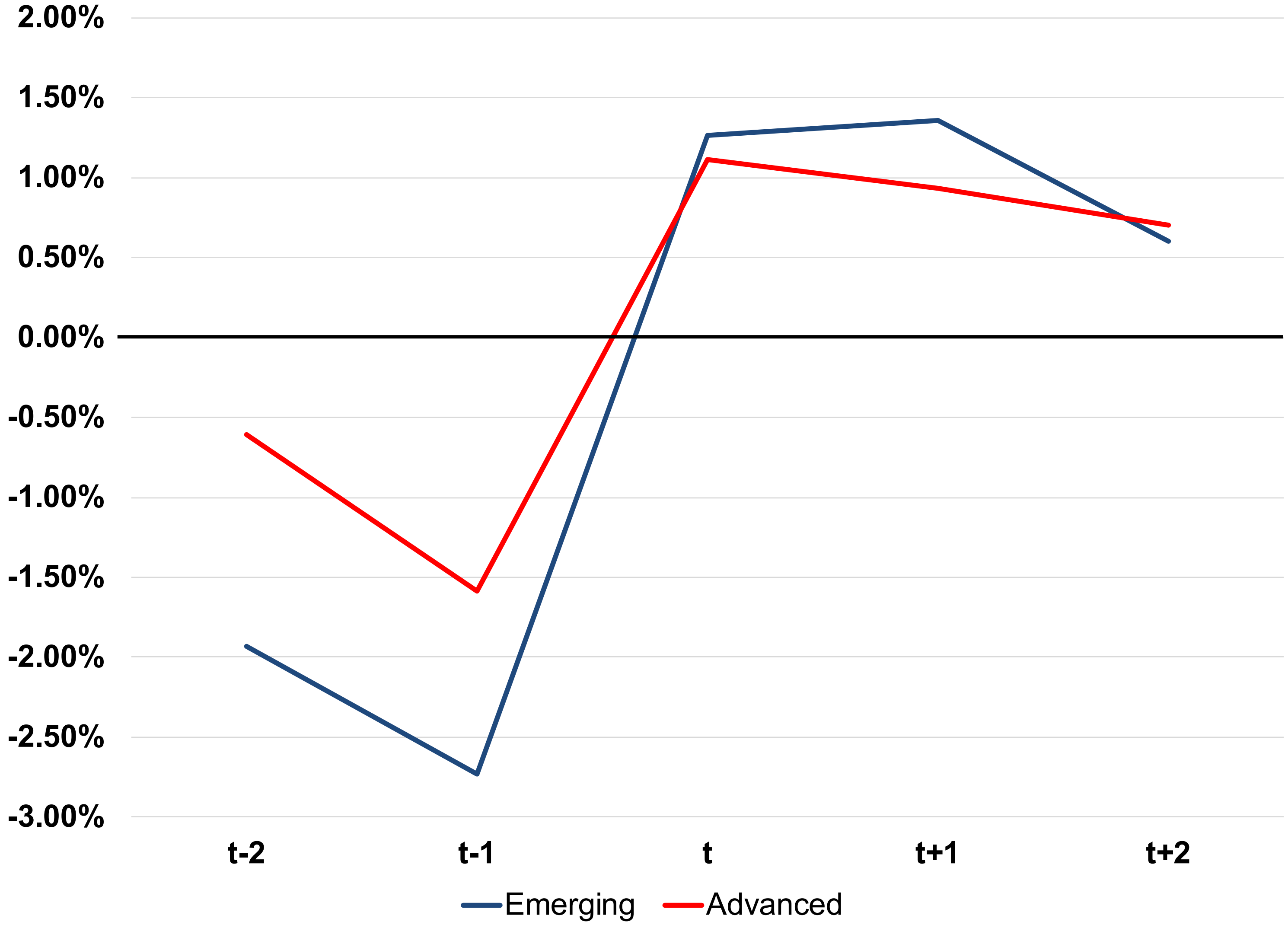
Defining and measuring Sudden Stops

- Large increases (95 percentile) in broadest measure of credit flow vis-à-vis rest of the world (*ca/y*) and market-wide EMBI or VIX
- Similar results using *ca/y* only
- Identify SSs in data for 35 EMs and 23 AEs over 1979-2016 period
- Construct event windows centered on SS dates for HP-filtered cyclical components of macro data

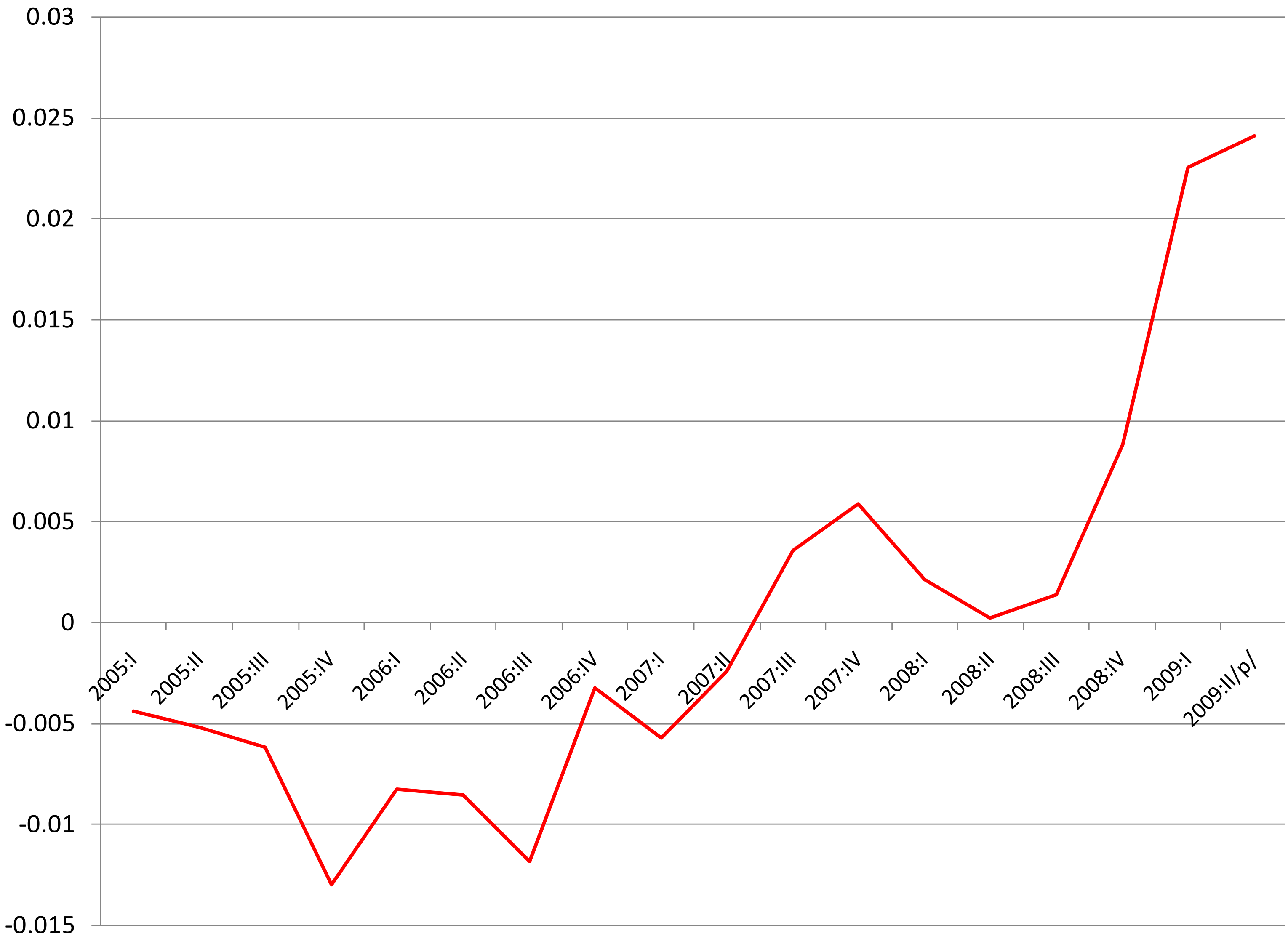
Stylized facts of Sudden Stops

1. SS events are infrequent: 53 total (2.6% freq.), 38 in EMs (3.2% freq.), 15 in AEs (1.7% freq.)
2. Clustered around "big events"
3. Preceded (followed) by expansions (contractions) in GDP, absorption, credit & leverage
4. Preceded (followed) by higher (lower) asset prices and real ex. rates
5. K,L account for small fraction of GDP drop, need to consider misallocation, cap. utilization (Mendoza (10), Meza (08), Calvo et al. (06))
6. Nested within regular business cycles

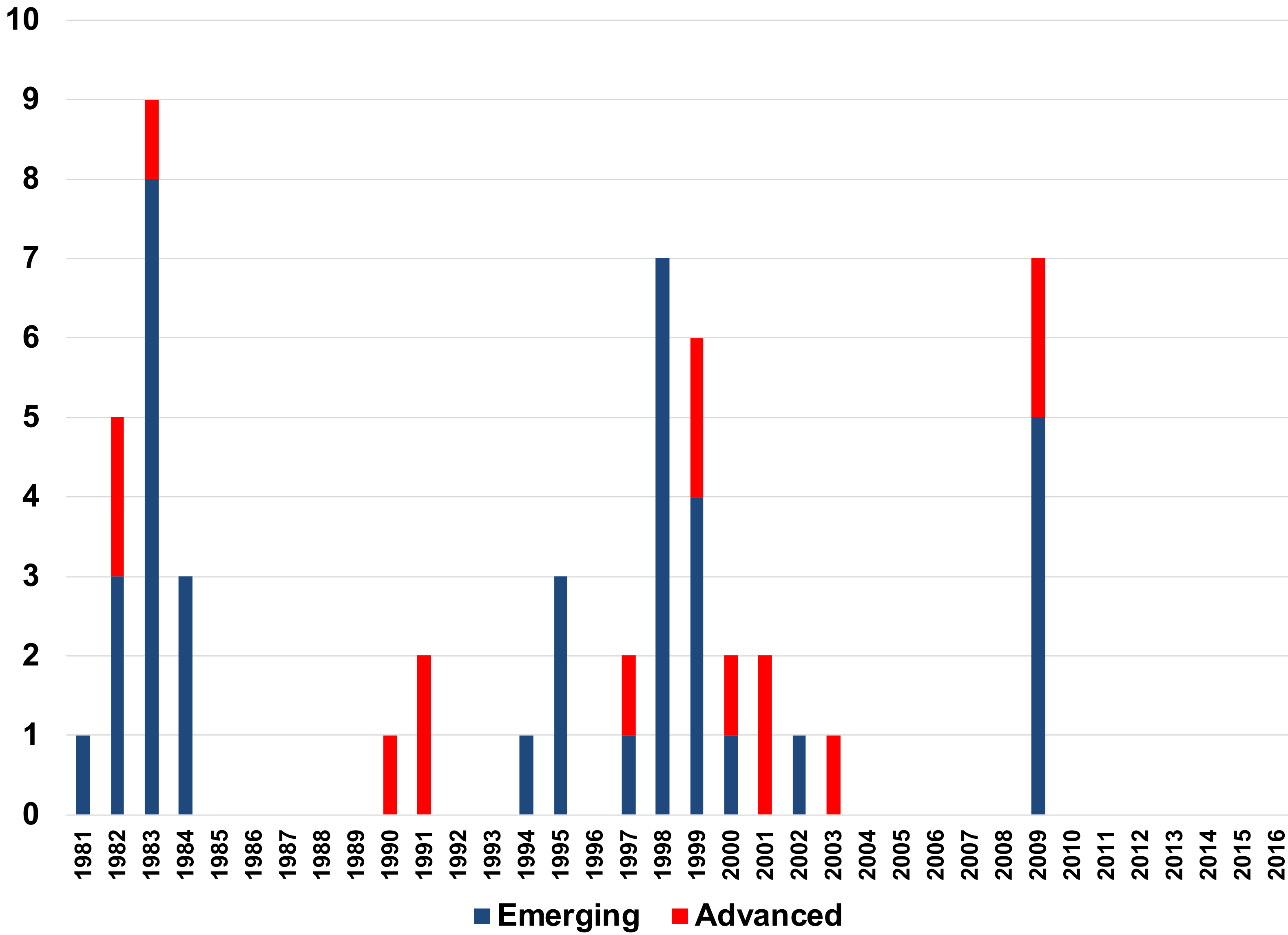
SS events: Current account-GDP ratio



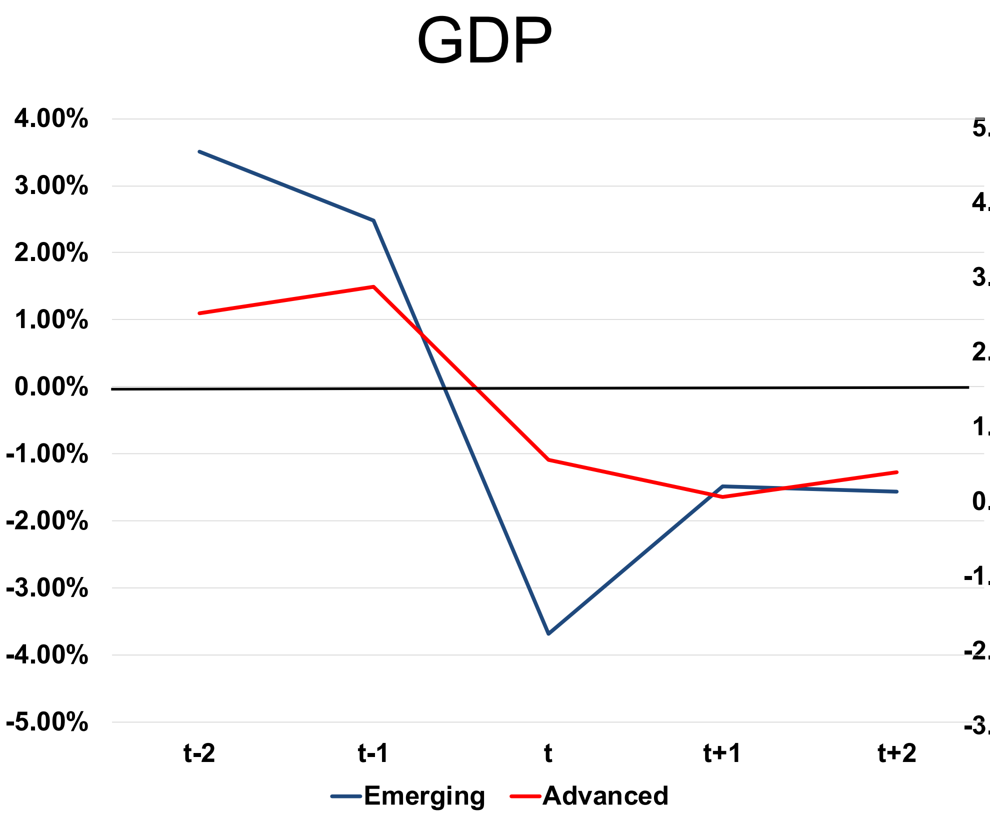
The U.S. Suddent Stop of 2008
(dev. from mean in current account/gdp ratio)

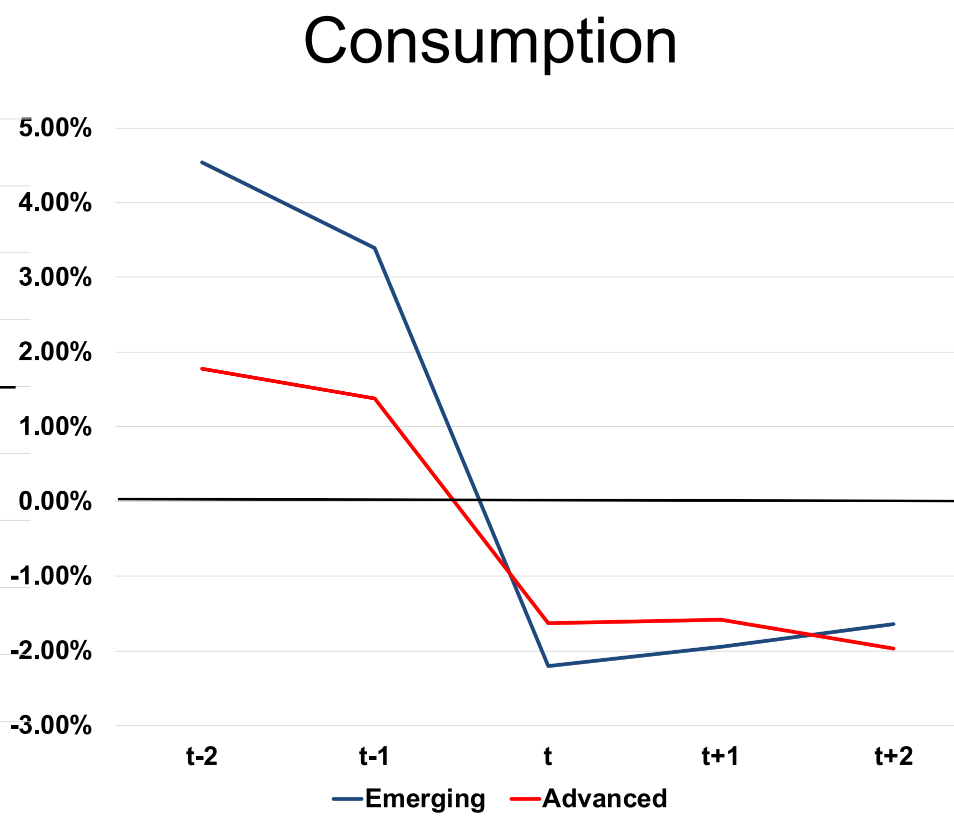


Clustering of Sudden Stops

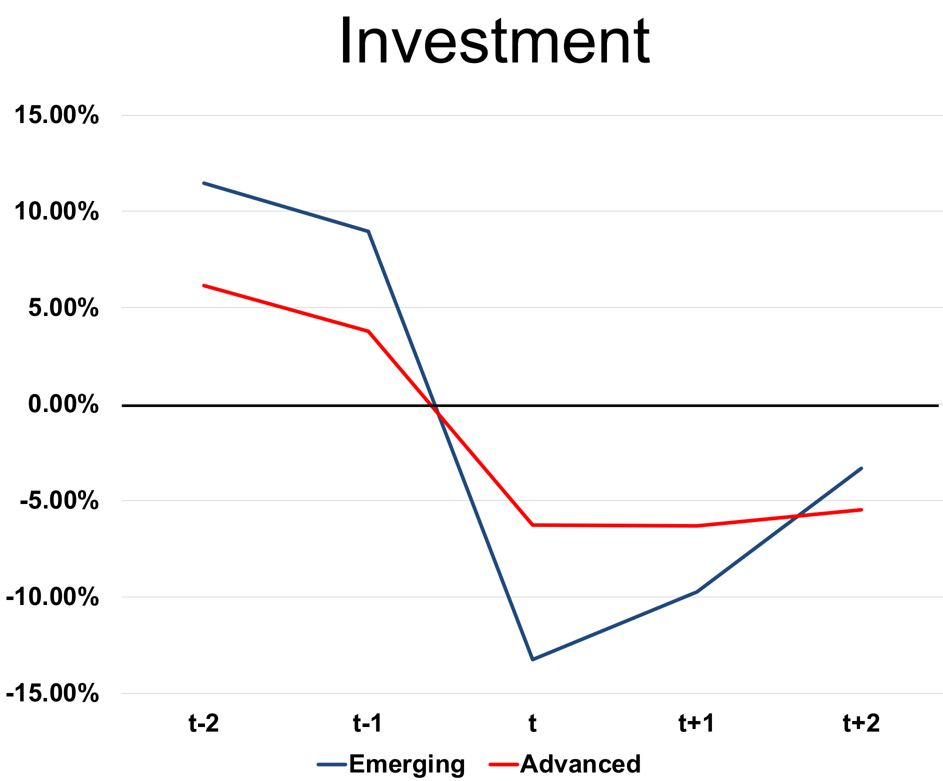


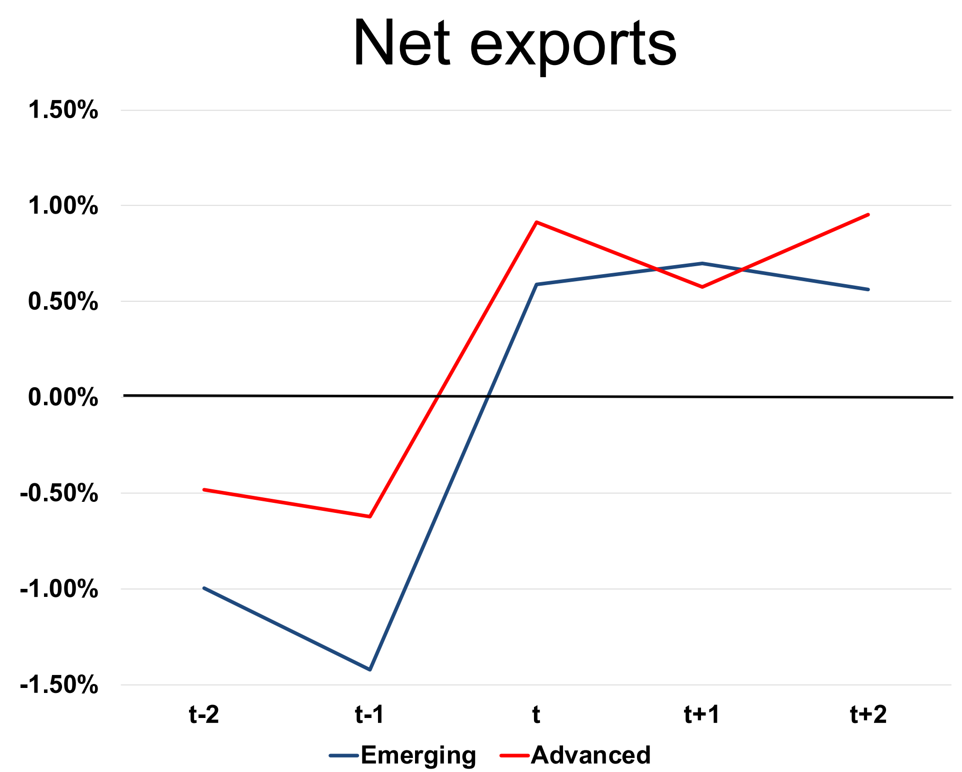
GDP & consumption during Sudden Stops



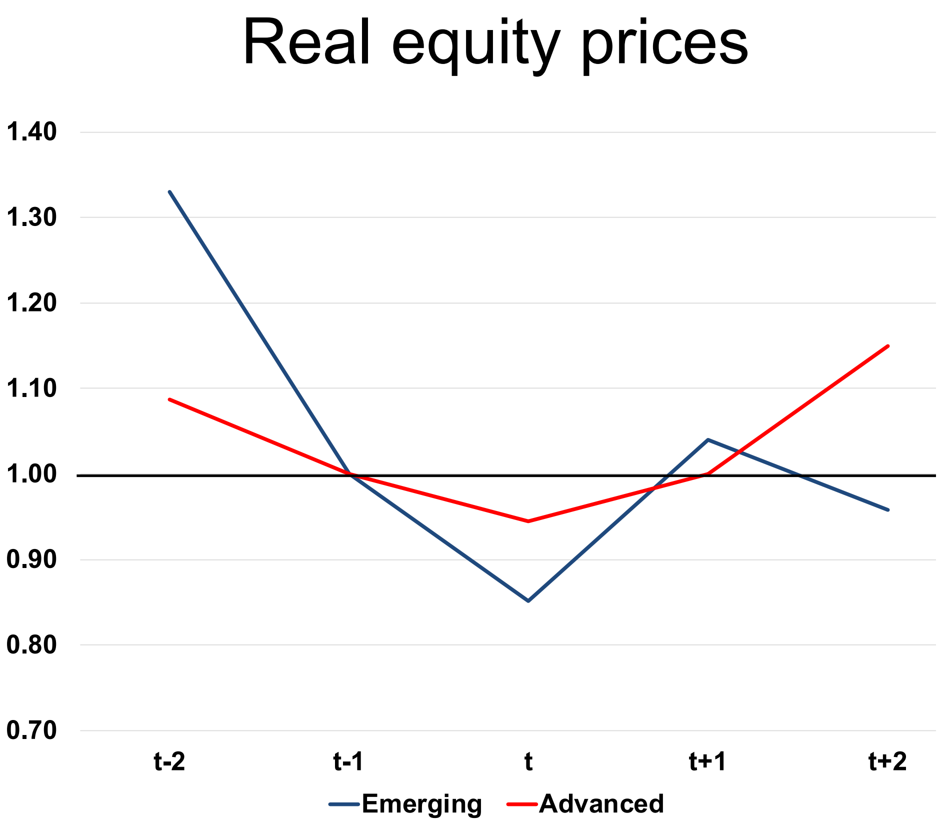


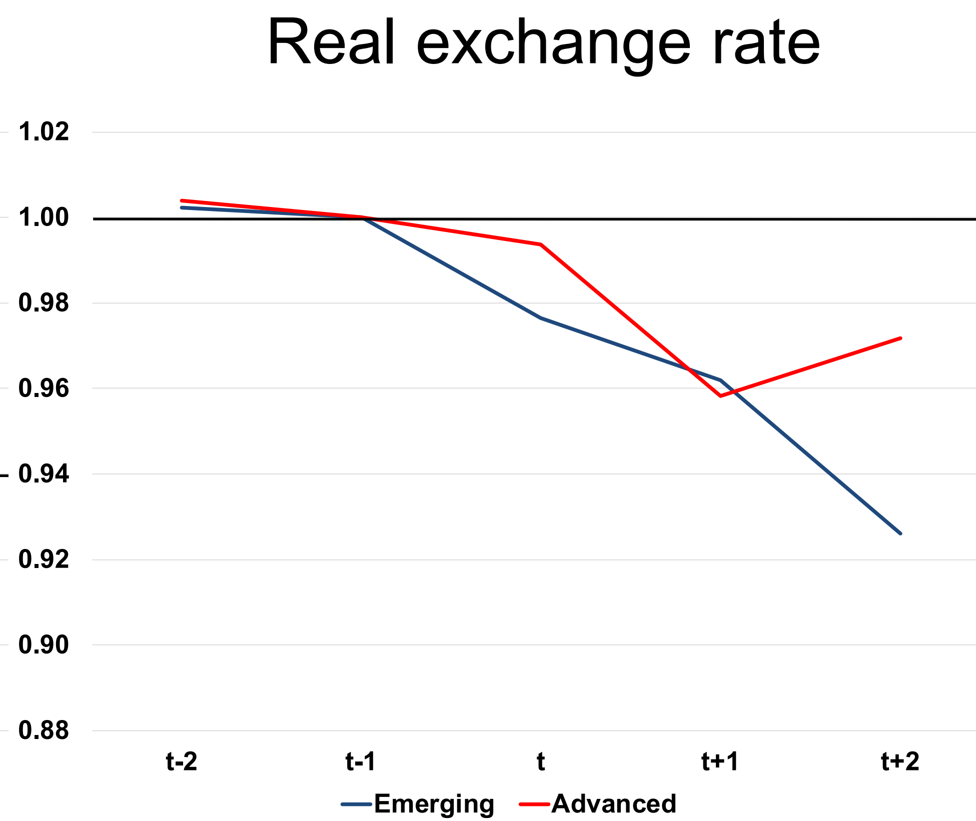
Investment & net exports during Sudden Stops





Equity prices & real ex. rates during Sudden Stops





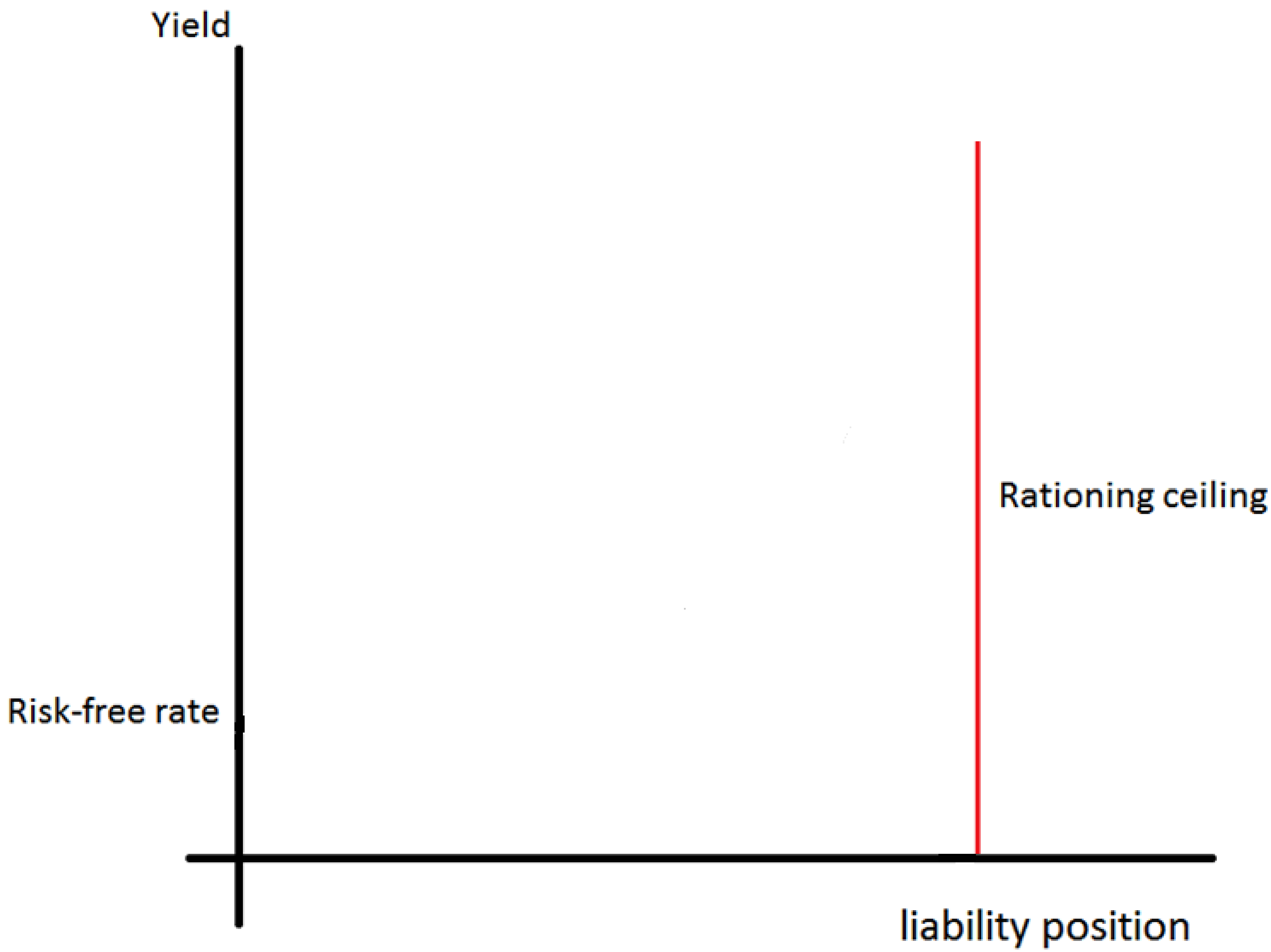
Basics of a Quantitative (Nonlinear) Approach to Modeling Financial Crises

Financial crises & incomplete markets: A writer's perspective

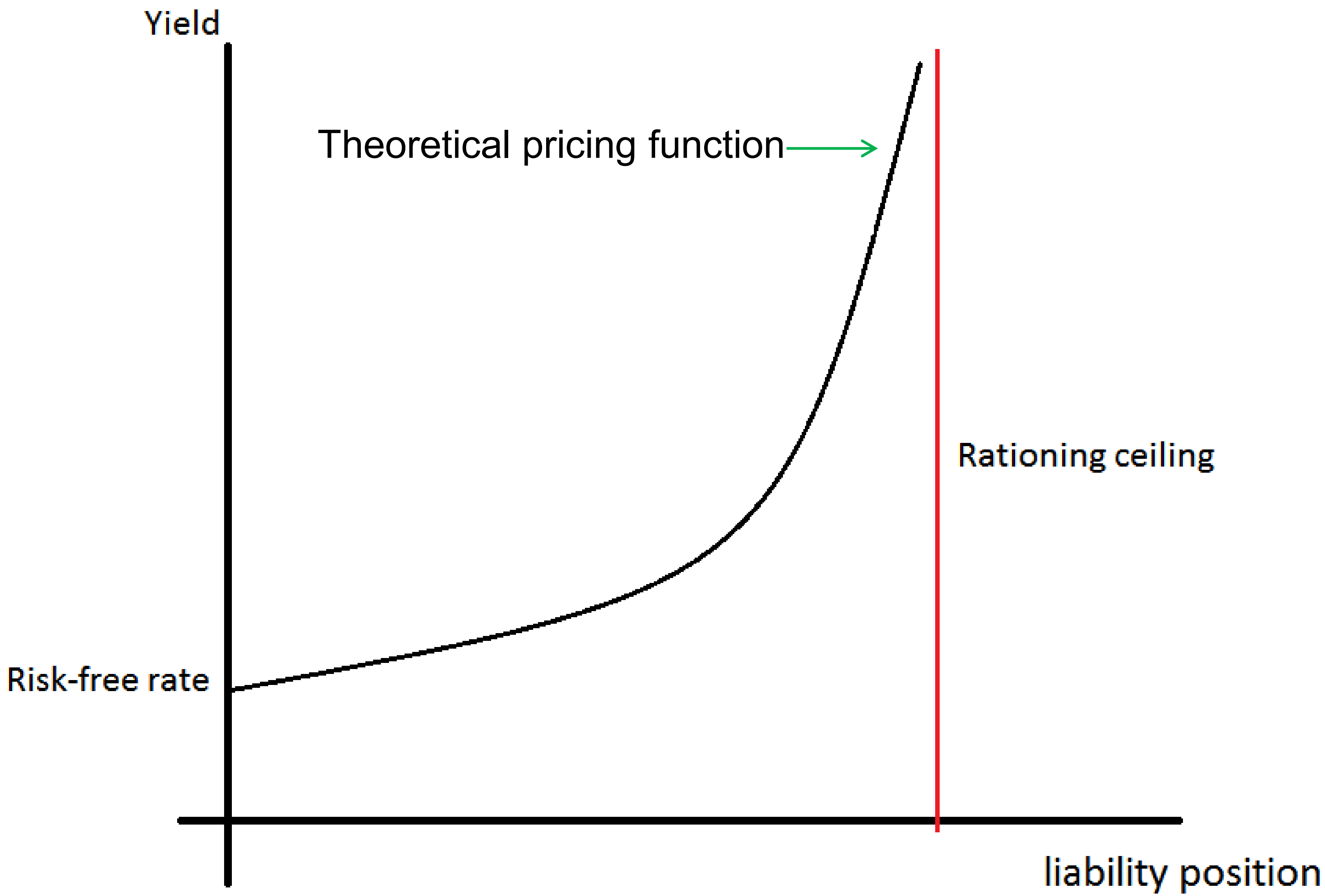
"…debt happens as a result of actions occurring over time. Therefore, any debt involves a plot line: how you got into debt, what you did, said and thought while you were there, and then—depending on whether the ending is to be happy or sad—how you got out of debt, or else how you go further and further into it until you became overwhelmed by it, and sank from view."

(Margaret Atwood, "Debtor's Prism," *WSJ*, 09/20/2008)

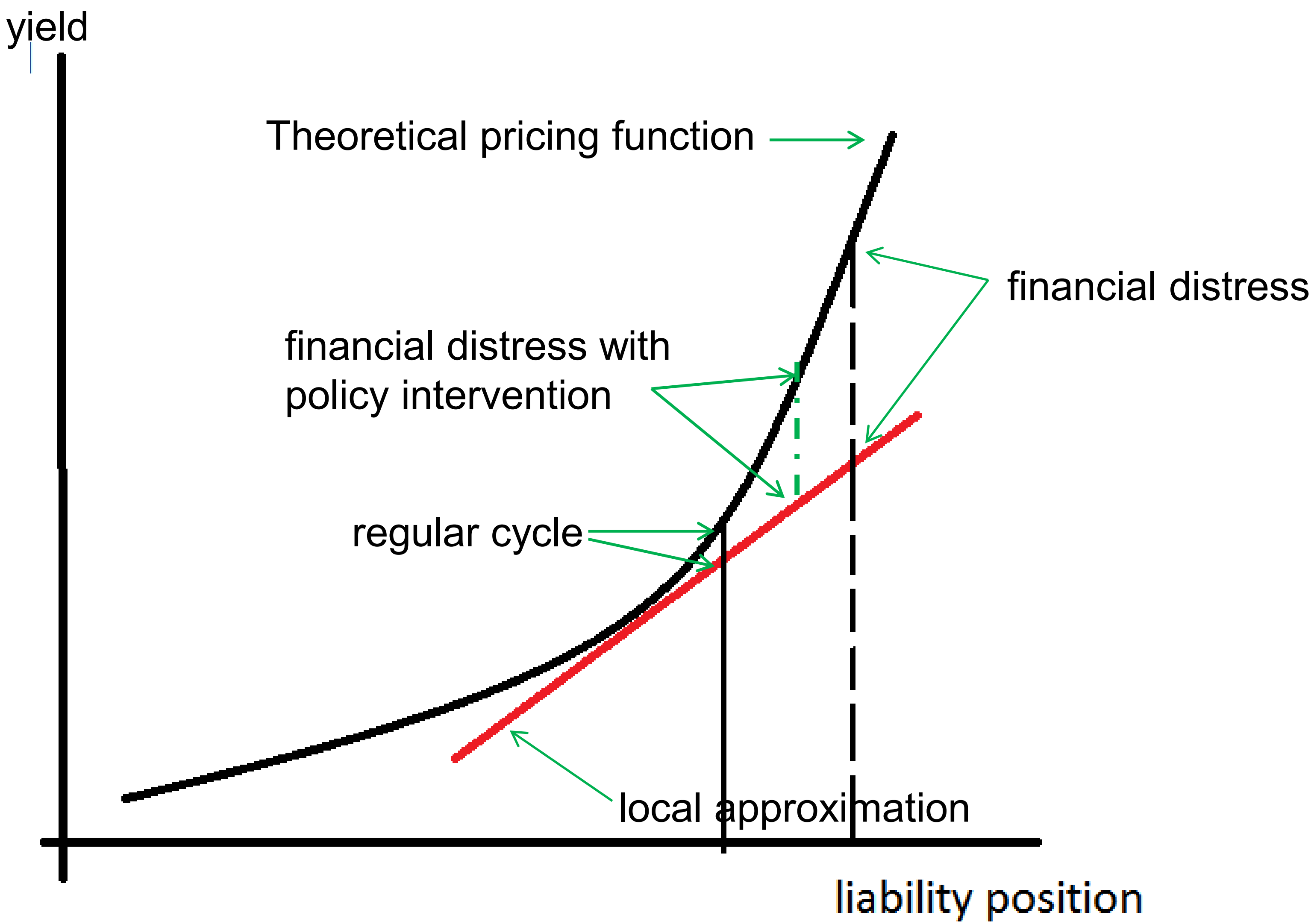
Pricing liabilities with financial distress



Pricing liabilities with financial distress



Amplification, nonlinearities and MPP



“Black swans,” nonlinearities and amplification

- *“Things are not conceptually out of control, this is not some mystery black swan we don’t understand and we need to rewrite all the paradigms because all the modeling is wrong.* ***If people are acting using a linear model, what looks like a ten-sigma event can actually be a two-sigma event****...”*
- *“Most of the models in credit, in trading desks, in macro models do quite well locally, the problem is when you stop being locally nonlinearities are really quite large,…If you want to see what happened in AIG…they wrote a whole lot of credit default swaps…the assets underlying them went down not one shock, not two shocks, not three shocks, but over and over. Each time* ***the same size shock is going to create something even larger****…”*

R. Merton, *“Observations on the Science of Finance in the Practice of Finance,”* (Muh Award Lecture, 03/05/2009)

LIMITATIONS OF THE FINANCIAL CRISES LITERATURE & LESSONS FROM FISHERIAN MODELS

Limitations of the literature

1. SS events as surprises (large, unexpected or MIT shocks)
   - Calvo (98), Gertler et al. (07), Christiano et al. (04,14), Caballero & Krishnamurty (01), Cook & Devereux (06), Smets et al. (14)…
   - Agents do not take financial frictions, possibility of SSs into account
2. Financial frictions often examined as local perturbations to deterministic equilibria in which constraints always bind
   - Cannot generate crises nested within common cycles (amplification and asymmetry in response to standard shocks)
   - Abstracts from nonlinear effects caused by occasionally binding constraints that depend on prices (Fisher's debt deflation channel)
3. Quantitative relevance of credit frictions
   - Amplification effects may be too small (Kocherlakota (00))
   - Can they explain infrequent crises nested within normal cycles?

Kocherlakota's critique

$$c_t + k_{t+1} + b_{t+1} = k_t^{\alpha 1}(1)^{0.4-\alpha 1} + Rb_t - e_t, \quad e_1 = \Delta, e_t = 0 \ for \ t > 1$$

$$b_{t+1} \geq -q_t(1) \ \ or \ \ -q_t k_{t+1}$$

$$Kocherlakota's \ amplification \ coefficient: \ \frac{|x_i(\Delta) - x_{ss}|}{x_{ss}} \div \frac{\Delta}{x_{ss}}, \quad x_i = q_1, y_2$$

Potential Amplification of an Income Shock
With Various Capital Share Values

When $\beta = 0.97$ and $\alpha_2 = 0.4 - \alpha_1$

Value of Capital Share (α_1)	Amplification of Effect on Land Price $(Q_1 - Q_{ss})\,\Delta^{-1}/Q_{ss}$	Amplification of Effect on Output $(Y_2 - Y_{ss})\,\Delta^{-1}/Y_{ss}$
0.3	.008	.349
0.2	.006	.266
0.1	.004	.150

Lessons from Debt-Deflation (Fisherian) Models

1. Crises are *endogenous* response to *typical* shocks when leverage ratios are high (DTIs, LTVs)
   - High leverage is endogenous outcome preceded by booms
   - Prec. saving rules out largest crashes, lowers long-run prob. of crises (negligible effects on long-run cyclical moments)
2. Collateral constraints cause larger recessions in crisis events
   - Deflation of Tobin's Q causes investment collapse
   - Reduced access to working capital and relative price deflation reduce factor demands and cause contemporaneous output drop
3. Large amplification and asymmetry
   - Financial crises nested within regular cycles
   - Standard SOE-DSGE results if credit constraints do not bind
4. Consistent with several key stylized facts (except size of asset price drop and credit booms)
5. Market failure (pecuniary externalities) justifies policy action

Analytical foundations of Fisherian models

Fisherian models of financial crises

- Fisherian models feature collateral constraints in which collateral is valued at market prices
- In Fisher’s 1933 article, financial amplification via these constraints had two pillars: Debt-deflation mechanism & interaction of innovation and agents’ beliefs
- In these models financial crises are endogenous outcomes of standard shocks driving regular business cycles, not large, unexpected (MIT) shocks
- Fisherian models include various well-known financial frictions models (Kiyotaki-Moore, Bernanke-Gertler, Giacoviello, Brunnermeier-Sannikov), but quantitative applications need nonlinear, global methods

Fisherian collateral constraints

- Debt limited by a fraction of market value of assets or incomes:

1. **Debt-to-income (DTI) or flow models**: debt in units of tradables limited to a fraction of market value of income (Mendoza (02), Benigno et al (13), Bianchi (11), etc.)

$$b_{t+1} \geq -\kappa \left(y_t^T + p_t^N \overline{y}^N \right) \qquad b_{t+1} \geq -\kappa(\pi_t + w_t l_t)$$

2. **Loan-to-value (LTV) or stock models**: debt cannot exceed a fraction of the market value of assets posted as collateral:

- International equity trading (Mendoza & Smith (06), Durdu & Mendoza (06))

$$b_{t+1} \geq -\kappa q_t \alpha_{t+1} K$$

- Debt secured with a fixed asset (Boz & Mendoza (14)))

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

- LTV with working capital (Mendoza (10), Bianchi & Mendoza (18)):

$$-\frac{b_{t+1}}{R} + \theta w_t n_t^d \leq \kappa q_t k_{t+1}$$

Key features of Fisherian amplification

1. Debt-deflation mechanism: When constraint binds, agents fire sale assets/goods, prices fall, lower prices tighten constraint further, forcing more fire sales
   - Credit crunch triggers collapse in demand, and supply also falls if the crunch affects factor demands (e.g., working capital, deflation of marginal products)
   - Different from Keynesian disequilibrium: price flexibility, rather than rigidity, and insufficient aggregate demand and supply
2. Pecuniary externality: agents do not internalize effect of individual borrowing on market price of collateral
   - Dynamic externality: effect of today's borrowing on tomorrow's prices if there is a financial crisis
   - Financial regulator who internalizes this borrows less and increases social welfare (macroprudential regulation)

Endogenous financing premia

1. Higher effective real interest rate ($R_{t+1}{}^{h} \equiv \lambda_t / E_t\left[\lambda_{t+1}\right]$)

$$0 < \lambda_t = E\left[\lambda_{t+1}\right] R + \mu_t \leq 1, \qquad E_t\left[R^h_{t+1} - R\right] = \frac{\mu_t}{E_t \quad \lambda_{t+1}}$$

2. Higher excess asset returns, lower prices:

$$E_t\left[R^q_{t+1} - R\right] = \left(\frac{\mu_t \ (1-\kappa) - \mathrm{cov}_t(\lambda_{t+1}, R^q_{t+1})}{E_t[\lambda_{t+1}]}\right)$$

$$q_t = E_t\left(\sum_{j=0}^{\infty}\left[\prod_{i=0}^{j}\left[E_t \quad R^q_{t+1+i}\right]^{-1}\right] d_{t+1+i}\right)$$

- *Direct* effect: $\mu_t\,(1\text{-}\kappa) \rightarrow$ requires limited ability to leverage!
- *Indirect* effect: $\mathrm{cov}\,(u'(.), R^q)$

3. Higher marginal fin. cost of inputs paid with working capital

$$e^A_t f_v(\cdot) = p^v e^v_t \left[1 + \phi(r + \mu_t R)\right]$$

Workhorse model with DTI constraint

(Mendoza, Economia 2005))

- Perfect-foresight, two-sector model (akin to Workhorse model 1):

$$\max_{\{c_t^T, c_t^N, b_{t+1}\}_0^\infty} \sum_{t=0}^{\infty} R^{-t} u\Big(c(c_t^T, c_t^N)\Big), \qquad c(\cdot)\ is\ CES$$

s.t.

$$c_t^T + p_t^N c_t^N = y_t^T + p_t^N \bar{y}^N - b_{t+1} + R b_t$$

$$b_{t+1} \geq -\kappa(y_t^T + p_t^N \bar{y}^N)$$

- With perfect credit markets, or if constraint does not bind: perfectly-smooth case of Permanent Income Theory
  - *"Wealth-neutral shocks"* to ${y_0}^T$ do not alter equilibrium

- When the constraint binds: amplification & asymmetry in c, p^n, ca
  - ca reversal produced by DD channel, not by assumption and more than a one-shot balance sheet effect (as in Calvo (98))

UNCONSTRAINED EQ AT t=0

1) Nontradables consumption

$$c_t^N = \bar{c}^{N,*} = \bar{y}^N$$

2) Tradables consumption

$$c_t^T = \bar{c}^{T,*} = (1-\beta)[PDV(y^T) + Rb_0]$$

3) Relative price

$$p_t^N = \bar{p}^{N,*} = MRS\left(\frac{\bar{c}^{T,*}}{\bar{y}^N}\right)$$

4) Current acct & bonds (debt)

$$b_1^* = y_0^T - \bar{c}^{T,*} + Rb_0$$

CONSTRAINED EQ AT t=0

1) Nontradables consumption

$$c_t^N = \bar{c}^{N,*} = \bar{y}^N$$

2) Tradables consumption

$$c_0^{T,SS} = y_0^T - b_1^{SS} + Rb_0 < \bar{c}^{T,*}$$

3) Relative price

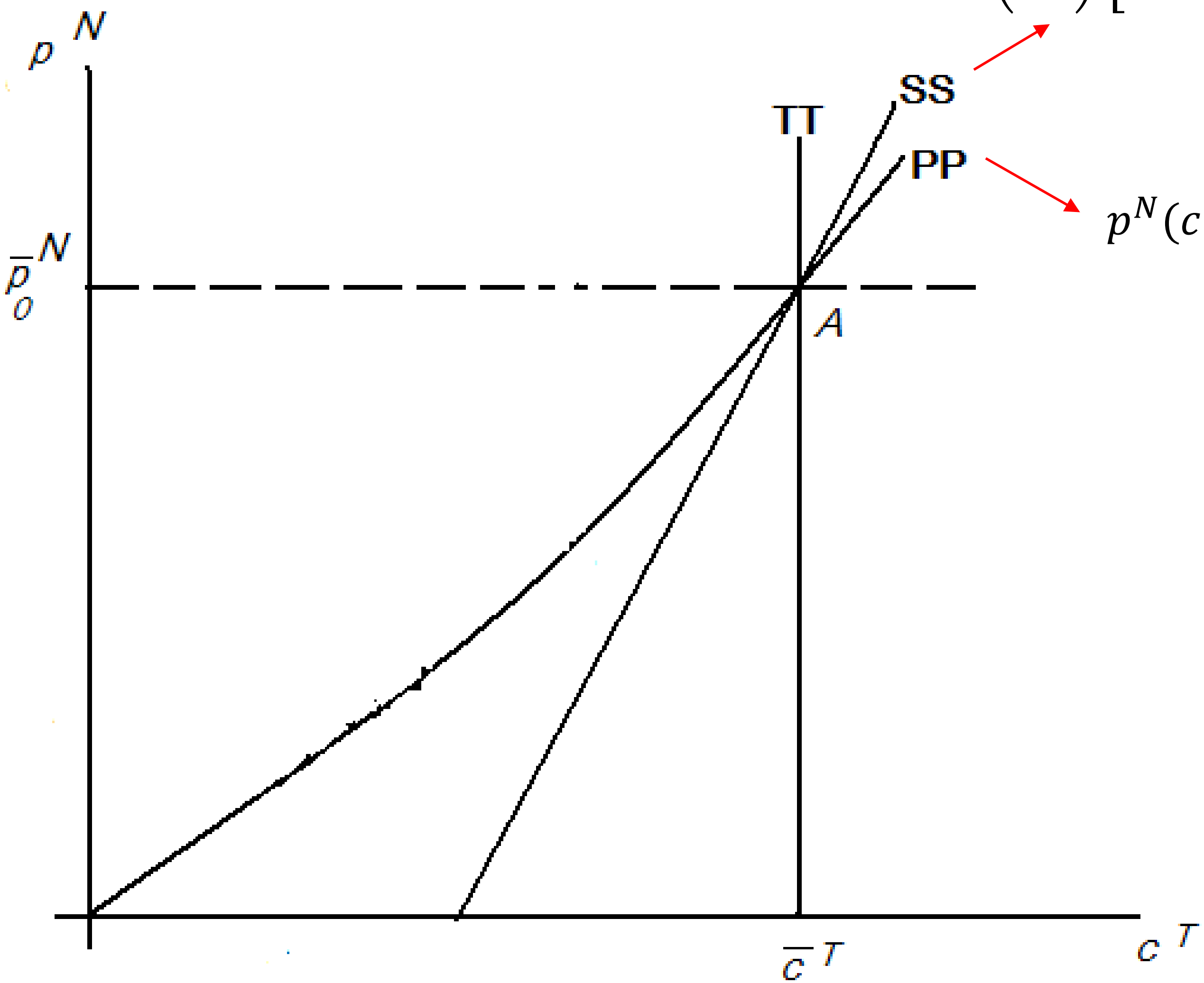
$$p_0^{N,SS} = MRS\left(\frac{y_0^T - b_1^{SS} + Rb_0}{\bar{y}^N}\right) < \bar{p}^{N,*}$$

4) Current acct & bonds (debt)

$$b_1^{SS} = -\kappa(y_0^T + p_0^{N,SS}\bar{y}^N)$$
$$> b_1^* = -\kappa(y_0^T + \bar{p}^{N,*}\bar{y}^N)$$

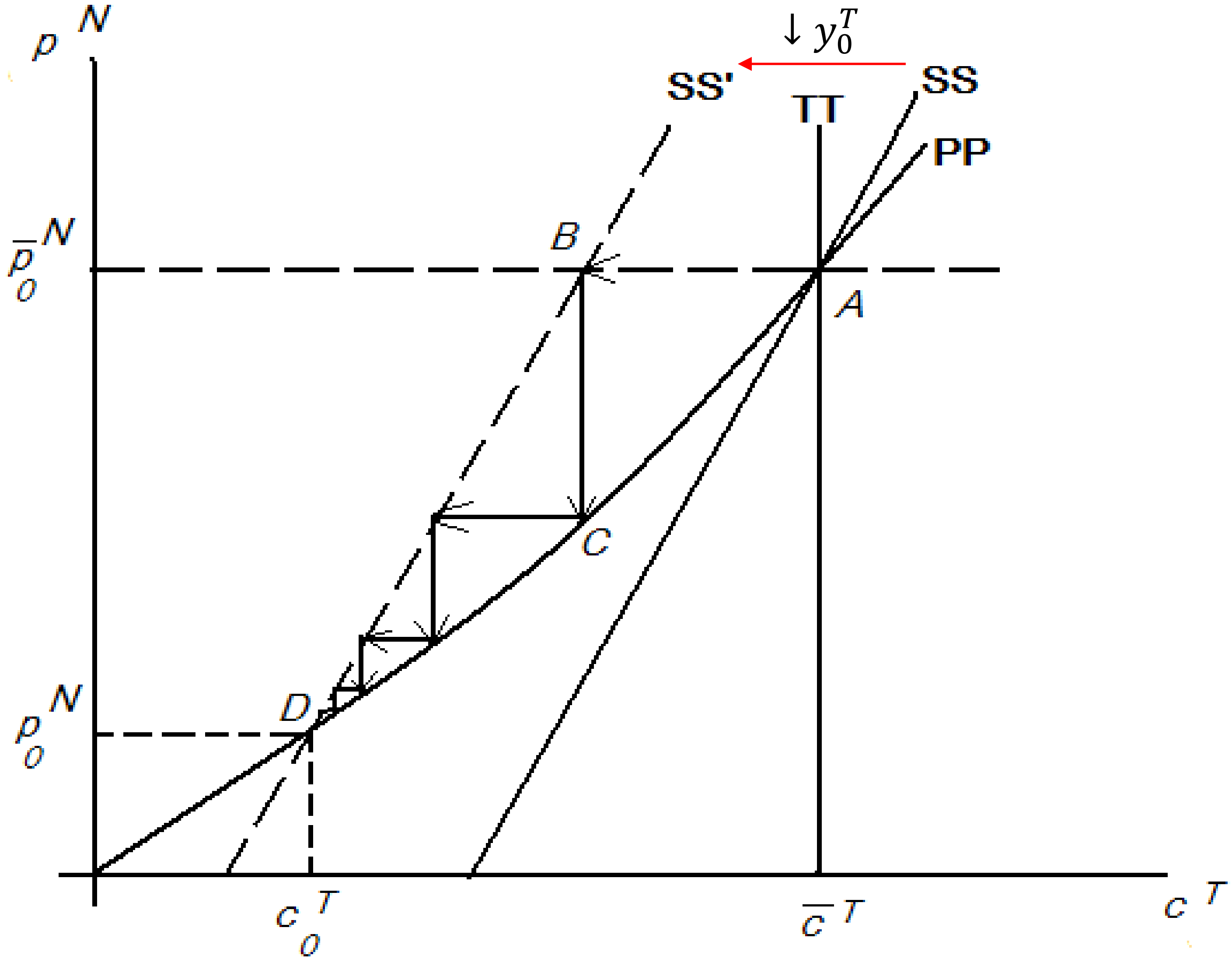
Equilibrium if constraint does not bind

$$p^N(c^T) = \left(\frac{-1}{\kappa}\right)\left[\frac{(1+\kappa)y_0^T + Rb_0}{\bar{y}^N}\right] + \left(\frac{1}{\kappa}\right)\left[\frac{c^T}{\bar{y}^N}\right]$$



$$p^N(c^T) = MRS\left(\frac{c^T}{\bar{y}^N}\right)$$

Fisherian amplification mechanism



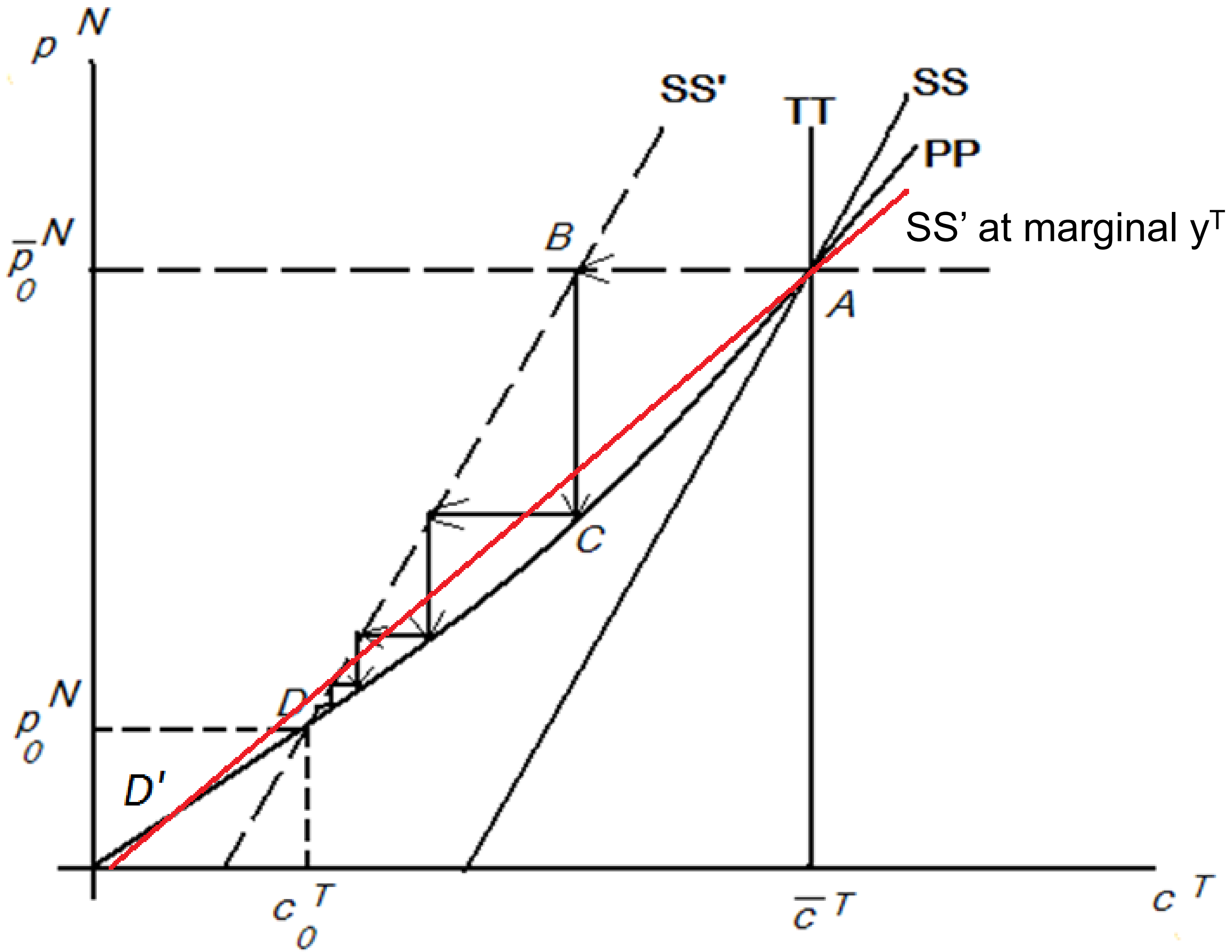
What about equilibrium multiplicity?

- Always two intersections between SS' and PP, but not always multiple equilibria
- If PP is flatter than SS at A, point D is a unique eq.
  - The second intersection has more debt and higher p^N than at A (which implies higher c^T at t=0 than in future, and hence debt is not constrained at t=0!)
- Multiple equilibria require two conditions:
  1. PP steeper than SS at point A:

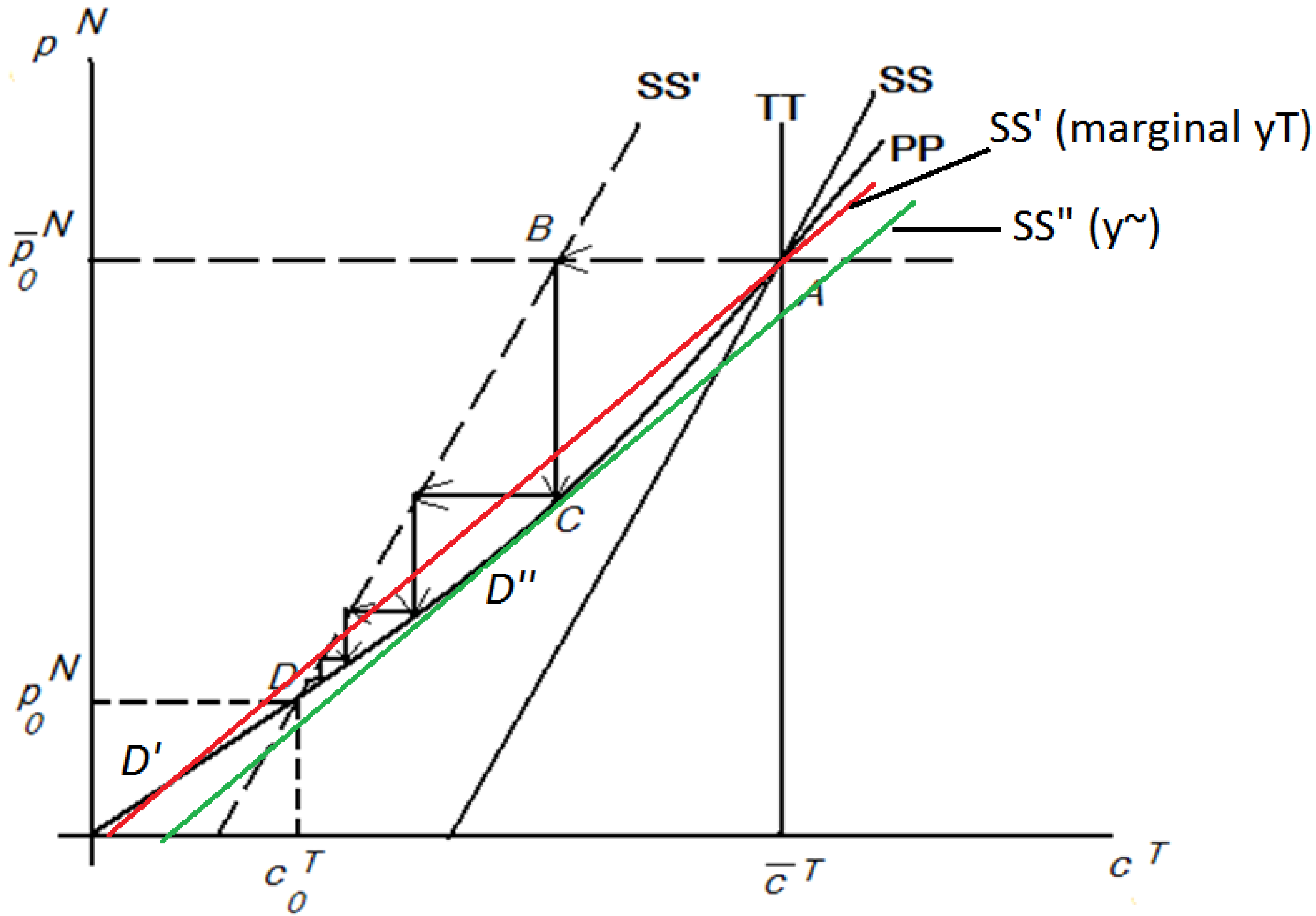
$$\kappa \geq \frac{1}{1+\mu}\left(\frac{\overline{c}^T}{\overline{p}_0^N \overline{y}^N}\right)$$

     - Depends on relatively high DTI cap or relatively low elasticity of subs. and/or ratio of T /N consumption
  2. Favorable income shocks in the "right" interval

Two equilibria at the marginal income shock



Equilibrium multiplicity range



Quantitative application

- Functional forms:

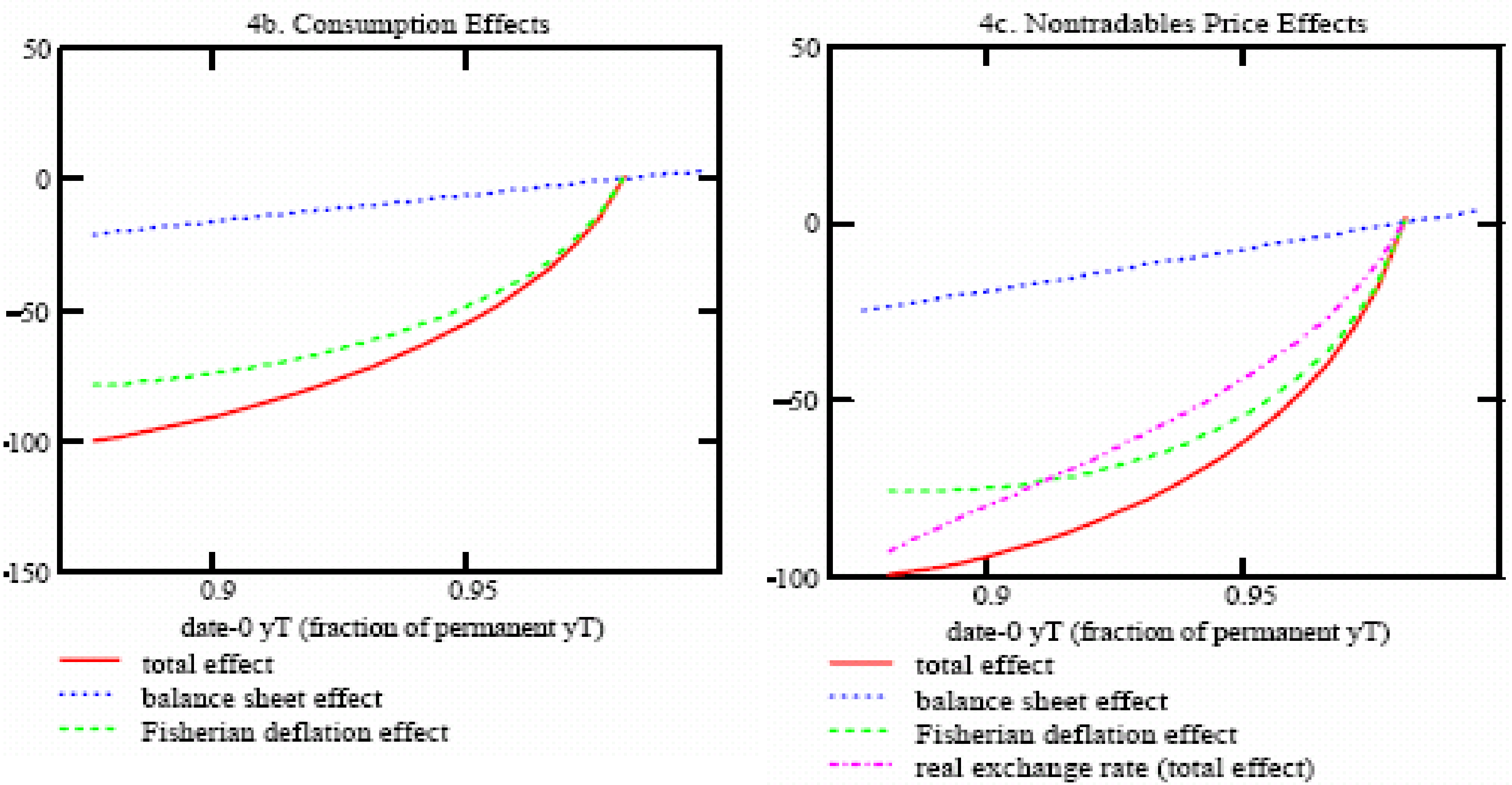
$$u(c) = c^{1-\sigma} \; /(1-\sigma) \qquad\qquad c = \left[a(c^T)^{-\mu} + (1-a)(c^N)^{-\mu} \right]^{-1/\mu}$$

- Parameter values:
  - β = 0.96, σ = 2
  - Mendoza's (02) estimates for Mexico:

    a = 0.342, $y^T/(p^N y^N)$ = 1.543, c^T/y^T = 0.66, c^N/y^N = 0.71
  - μ = 0.204, $1/(1+\mu)$ = 0.83 upper bound of estimates for LA
  - Initial foreign debt set at 1/3 of GDP
  - Credit limit set at κ = 1/3
  - Permanent output normalized to 1

Financial amplification effects

- Effects of 5% wealth-neutral shock to y_0^T (transitory TOT shock):
  - $\downarrow b_1$ by 15 pp. of permanent income
  - c_0^T and p_0^N nearly 60 % below eq. with perfect credit markets.
  - DD mechanism contributes all but 3 pps.



Limitations of this experiment

- It only tells us that very bad things can happen if credit access stops suddenly and unexpectedly
- It doesn't tell us:
  - How knowing this may happen affects borrowers' behavior before the credit crunch (adapting to possibility)
  - What magnitudes of shocks trigger the credit constraint?
  - How large are the financial amplification effects?
  - What is the probability of observing credit crises?
  - Is this a useful approach to model financial crises (i.e. can it explain the stylized facts?)
- …but it does illustrate potential for large financial amplification/asymmetry in macro responses to shocks!

Application I: Explaining the Surge in Reserves in the Globalization Era

Reserves as Self Insurance

(Durdu, Mendoza & Terrones, *JDE, 2009*)

- Is surge in reserves in EMs self-insurance against crises?
  - Compared with higher volatility and financial globalization
- Fisherian model with endogenous risk of financial crises via DTI constraint and imported intermediate goods
  - Quantify optimal amount of reserves as self insurance
  - Endogenous mapping between savings and prob. of crisis
- Key findings:
  1. Endogenous crises in response to typical shocks at high leverage
  2. Risk of crises causes large increase in NFA
  3. Self insurance reduces sharply long-run prob. of crises
  4. Slow adjustment with *ca* surpluses, undervalued *rer*'s
  5. Results robust to standard preferences v. endogenous discounting

Surge in reserves in Sudden Stop Countries

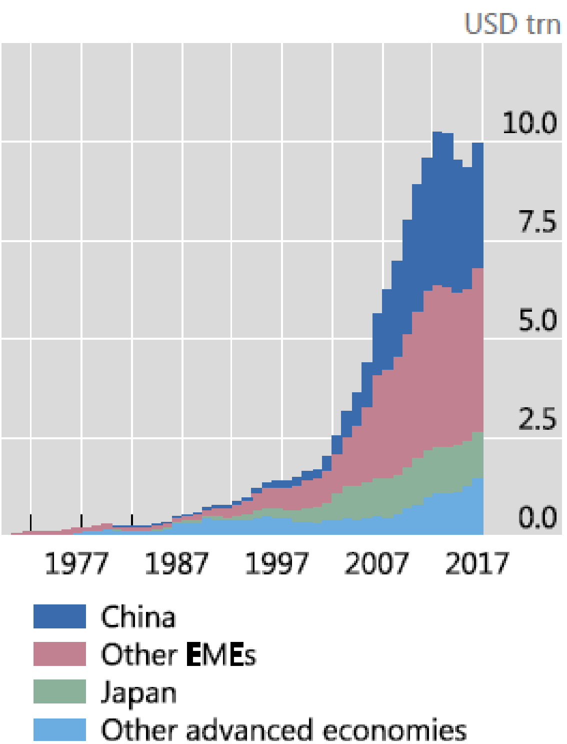
(difference of averages for SS year to 2005 minus 1985 to SS year)

Country	Year of Sudden Stop	Change in reserves
Hong Kong	1998	34.69
Korea	1997	16.23
Malaysia	1997	14.36
Thailand	1997	13.17
Uruguay	2002	12.87
Indonesia	1997	12.17
Philippines	1997	10.65
Russia	1998	9.41
Turkey	2001	7.90
Peru	1998	7.41
Pakistan	1998	6.61
Argentina II	2001	6.51
Argentina I	1994	5.42
Chile	1998	3.57
Brazil	1998	3.30
Colombia	1998	2.97
Mexico	1994	2.65
Ecuador	1999	-3.46
Median		7.66
Median Asian Countries		13.17

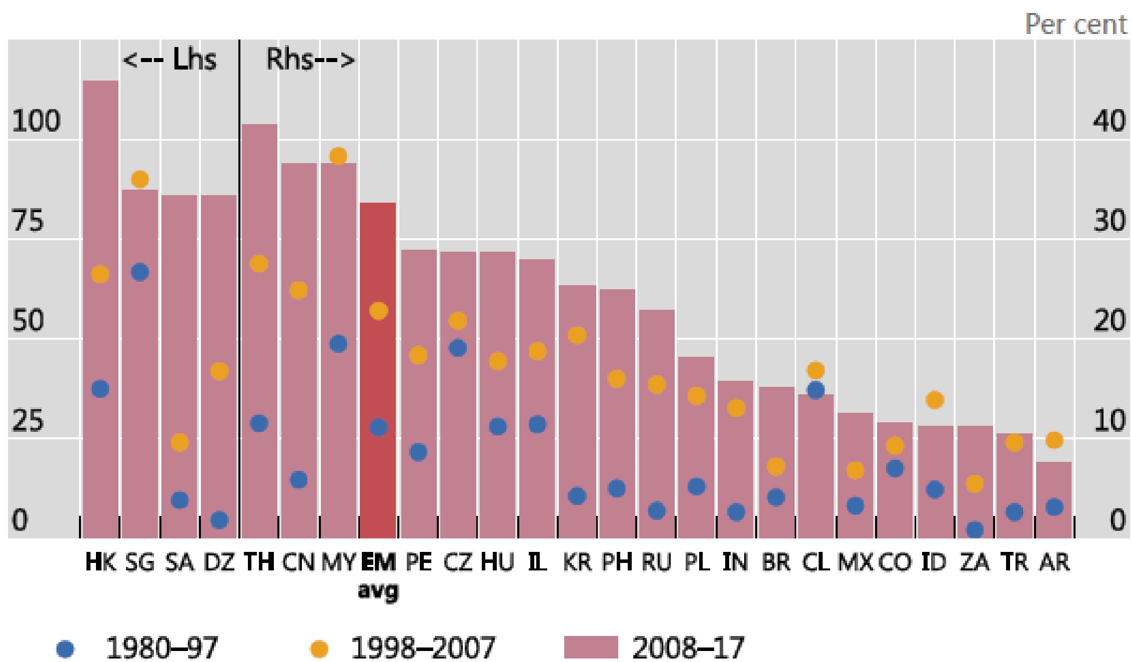
Update from the BIS

(Arslan and Cantu, 2017)

Volume of reserves[2]



Reserves relative to GDP



[1] AR = Argentina; BR = Brazil; CL = Chile; CN = China; CO = Colombia; CZ = Czech Republic; DZ = Algeria; HK = Hong Kong SAR; HU = Hungary; ID = Indonesia; IL = Israel; IN = India; KR = Korea; MX = Mexico; MY = Malaysia; PE = Peru; PH = Philippines; PL = Poland; RU = Russia; SA = Saudi Arabia; SG = Singapore; TH = Thailand; TR = Turkey; ZA = South Africa. [2] Only the EMEs listed in the right-hand panel.

Model structure

- Preferences:

$$E_0\left[\sum_{t=0}^{\infty}\left\{\exp\left(-\sum_{\tau=0}^{t-1} v(c_\tau)\right)\right\}\frac{c_t^{1-\gamma}}{1-\gamma}\right],$$

$$v(c) = \rho^{UE}\ln(1+c) \;\; or \;\; \ln(1+\rho^{BAH})$$

$$c(c_t^T, c_t^N) = \left[a\left(c_t^T\right)^{-\mu} + (1-a)\left(c_t^N\right)^{-\mu}\right]^{-\frac{1}{\mu}}, \quad a>0,\; \mu \geq -1.$$

- Households' budget constraint

$$c_t^T + p_t^N c_t^N = \varepsilon_t^T y^T - A^T + \pi_t^N - p_t^N A^N - b_{t+1} + b_t R$$

- DTI credit constraint

$$b_{t+1} \geq -\kappa \left[\varepsilon_t^T y^T + \pi_t^N \right]$$

$$where \quad \pi_t^N \overset{eq}{=} p_t^n y_t^n - p^m m_t$$

- Nontradables produced with imported inputs

$$y_t^N = z_t Z m_t^\alpha, \qquad 0 \leq \alpha \leq 1.$$

- Shocks to tradables endowment & nontradables TFP

Endogenous Sudden Stops

- Business cycles lead to binding borrowing constraint
  - Countercyclical current account
  - Long-run business cycle moments unchanged
- Fisherian DD amplifies effects of shocks causing crises:

$$\boxed{b_{t+1} = -\kappa\left[\varepsilon_t^T y^T + p_t^N (1-\alpha) z_t Z m_t^\alpha\right]}$$

$\downarrow c^T$

$$\boxed{p_t^N = \frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{1+\mu}}$$

$\downarrow p^N$

$$\boxed{p_t^N \alpha z_t Z m_t^{\alpha-1} = p^m}$$

$\downarrow m$

Planner's problem (socially optimal NFA)

$$V(b,\varepsilon^T,z)=\max_{b',m}\left\{\begin{array}{l}\dfrac{\left[\left[a\ \ c_t^{T\ \ -\mu}+(1-a)\ \ c_t^{N\ \ -\mu}\right]^{-\frac{1}{\mu}}\right]^{1-\gamma}}{1-\gamma}+\\ \qquad\exp\left(-v\left(\left[a\ \ c_t^{T\ \ -\mu}+(1-a)\ \ c_t^{N\ \ -\mu}\right]^{-\frac{1}{\mu}}\right)\right)E[V(b',\varepsilon^{T\prime},z')]\end{array}\right\}$$

subject to

$$c^T=\varepsilon^T y^T-b'+bR+A^T-p^m m$$

$$c^N=zZm^\alpha+A^N$$

$$b'\geq-\kappa\left[\varepsilon^T y^T+(1-\alpha)p^N zZm^\alpha\right]$$

$$p_t^N=\frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{1+\mu}$$

Calibration

ρ^{BAH}	Rate of time preference in the BAH setup	0.059
ρ^{UE}	Rate of time preference elasticity in the UE setup	0.187
γ	Coefficient of relative risk aversion	2.000
μ	Elasticity of substitution	0.316
a	CES weight of tradable consumption	0.341
ϕ	Ad-hoc debt limit	-0.700
α	Share of imported inputs	0.200
R	Gross world interest rate	1.059
b	Net foreign assets-GDP ratio	-0.440
p^N	Relative price of nontradables	1.000
p^m	Price of imported input	1.000
$y^T + p^N y^N - p^m m$	GDP in units of tradables	1.000
c^T/y^T	Tradable consumption-GDP ratio	0.665
$p^N c^N/(p^N y^N - p^m m)$	Nontradable consumption-GDP ratio	0.710
$(p^N y^N - p^m m)/y^T$	Nontradable-tradable GDP ratio	1.543
A^T	Lump-sum absorption of tradables	0.106
A^N	Lump-sum absorption of nontradables	0.176

Stochastic process of exogenous shocks

- VAR of tradables endowment, nontradables TFP
  - Tradables endowment = tradables GDP
  - Nontradables TFP first proxied with nontradables GDP
  - SMM for NT TFP to match nontradables variability, autocorrelation and correlation with tradables GDP

$$y_t = \rho \cdot y_{t-1} + e_t$$

$$\rho = \begin{bmatrix} 1.088 & 0.564 \\ -0.655 & 0.300 \end{bmatrix}, \quad \text{cova}(e) = \begin{bmatrix} 0.000601 & 0.00055 \\ 0.00055 & 0.0012 \end{bmatrix}$$

- Unconditional moments of the Markov chain:

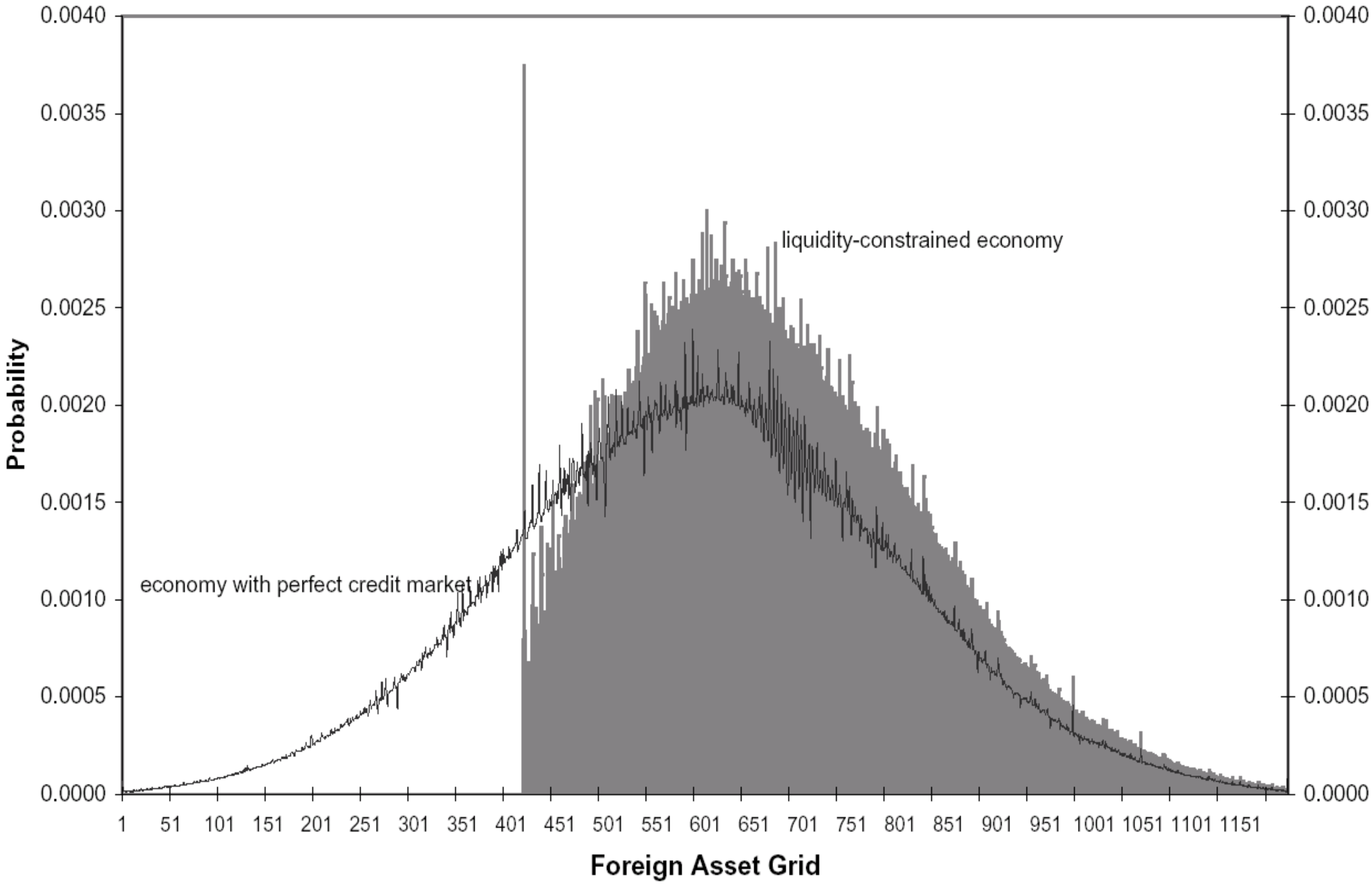
$$\hat{\sigma}_{y^T} = 0.0334\,, \; \hat{\sigma}_{y^N} = 0.0305\,, \; \hat{\rho}_{y^T} = 0.587\,, \; \hat{\rho}_{y^N} = 0.483\,, \text{ and } \hat{\rho}_{y^T,y^N} = 0.516$$

- Moments in the data:

$$\sigma_{y^T} = 0.0336 \quad \sigma_{y^N} = 0.0327 \quad \rho_{y^T} = 0.575 \quad \rho_{y^N} = 0.603 \quad \rho_{y^T,y^N} = 0.772$$

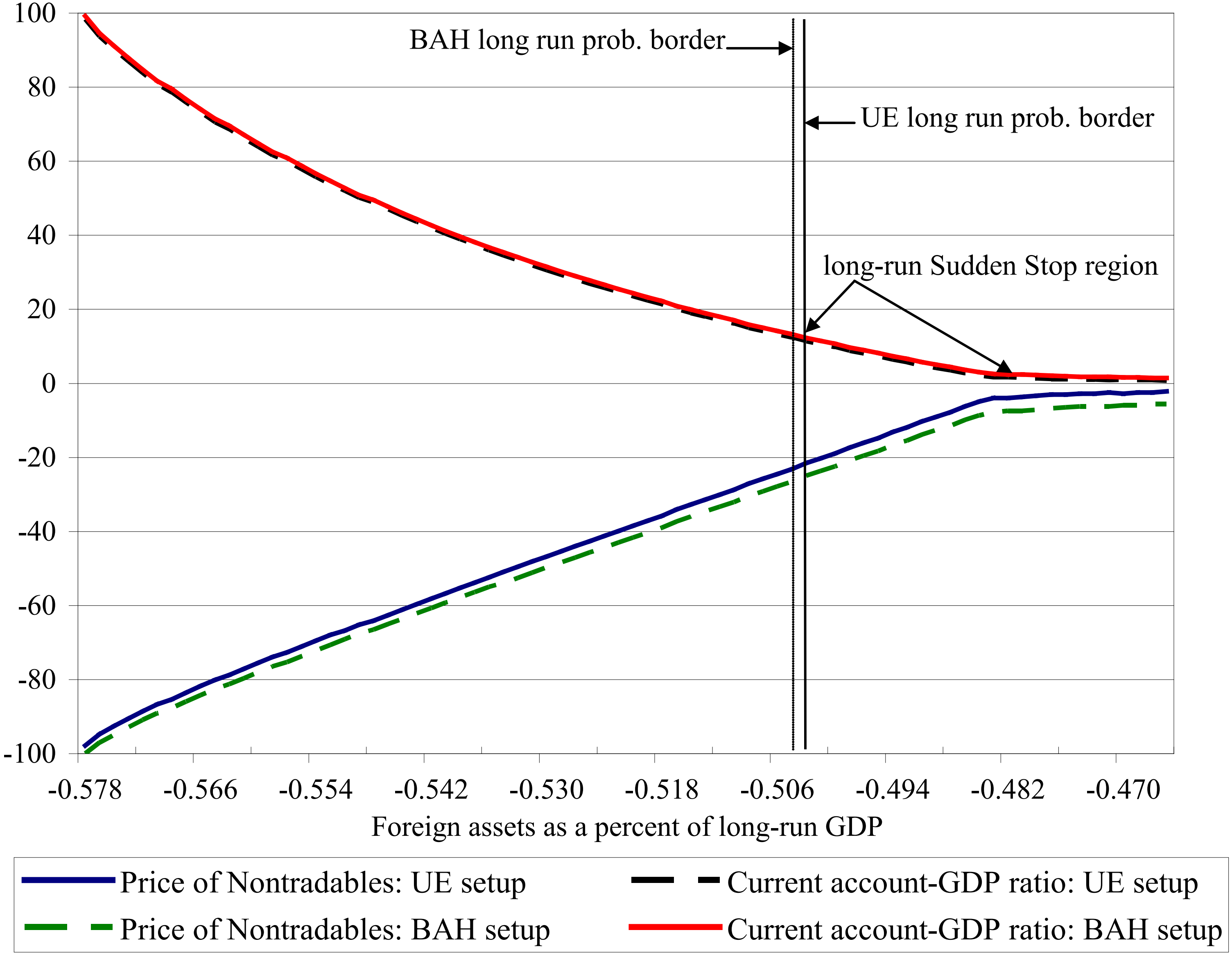
Long-run distribution of NFA

(model with endogenous discounting-UE)



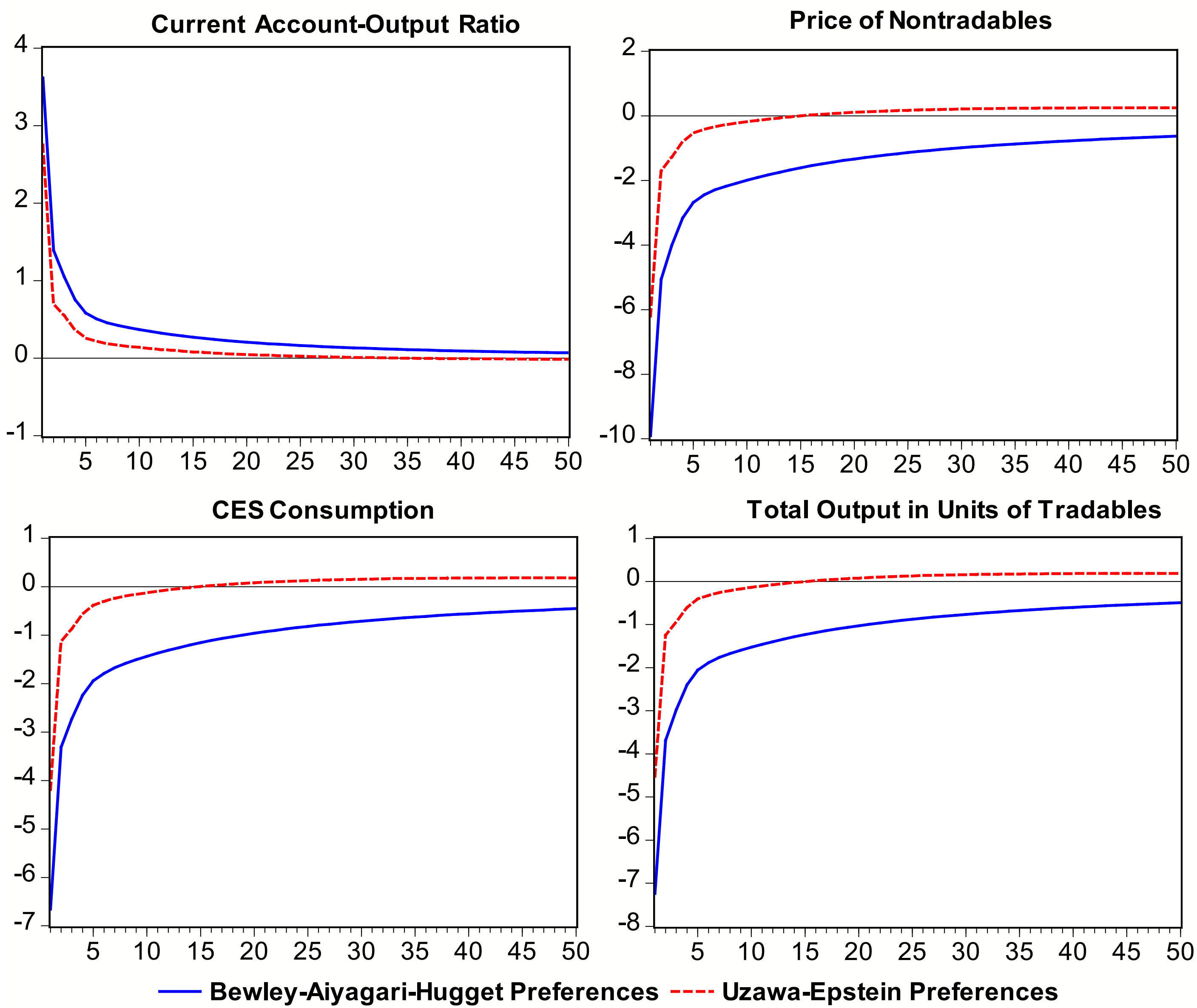
Impact amplification effects

(excess responses to 1 s.d. shocks)



Crisis dynamics at a 49% debt ratio

(excess responses to 1 s.d. shocks)



The magic of precautionary savings

Mean foreign assets and probability of a Sudden Stop at a -48.7% debt ratio

	BAH setup		UE setup	
	Prob. of Sudden Stop	Mean foreign assets	Prob. of Sudden Stop	Mean foreign assets
Economy with credit constraints				
year 0	100.0%	-48.7%	100.0%	-48.7%
year 2	40.0%	-48.2%	21.0%	-48.2%
year 15	4.7%	-41.7%	3.4%	-42.9%
long run	0.9%	-24.3%	1.1%	-37.8%
Frictionless economy				
long run	0.0%	-44.7%	0.0%	-42.4%
Change in mean foreign assets				
		20.4%		4.6%

Application II: Explaining Sudden Stops

Sudden Stops, Financial Crises and Leverage
(Mendoza, AER 2010)

- Equilibrium business cycle model with:
  - LTV collateral constraint on debt and working capital
  - Imported intermediate goods
  - Shocks to [R, p^v , TFP] taken from data
- Representative firm-household problem:

$$\max\left\{E_0\left[\sum_{t=0}^{\infty}\exp\left\{-\sum_{\tau=0}^{t-1}\rho\left(c_\tau - N(L_\tau)\right)\right\}u\left(c_t - N(L_t)\right)\right]\right\}$$

s.t.

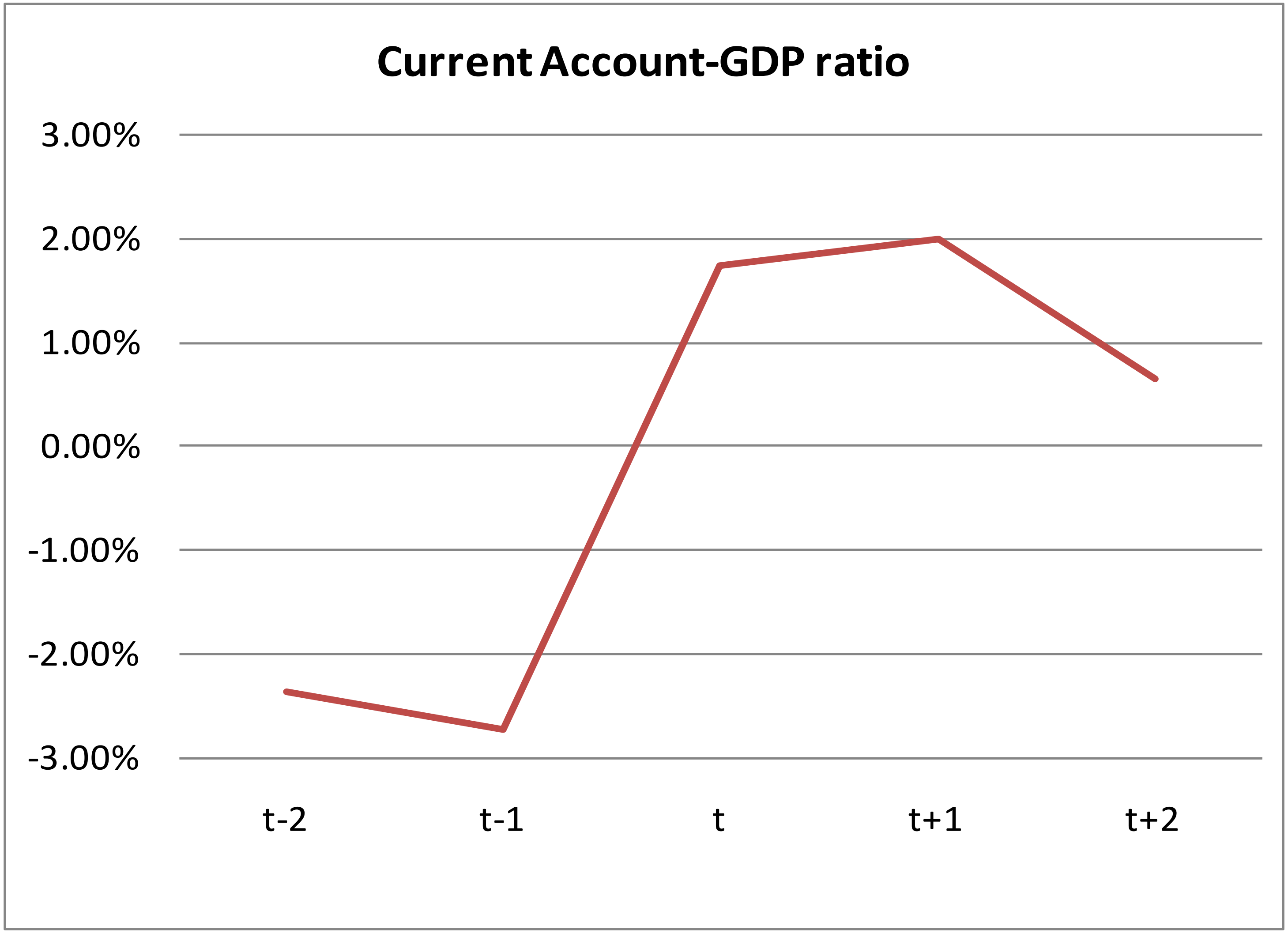
$$c_t + i_t + p_t v_t = \exp(\varepsilon_t^A)F(k_t, L_t, v_t) - \phi\left(R_t - 1\right)\left(w_t L_t + p_t v_t\right) - q_t^b b_{t+1} + b_t$$

$$i_t = \delta k_t + \left(k_{t+1} - k_t\right)\left[1 + \Psi\left(\frac{k_{t+1} - k_t}{k_t}\right)\right]$$

$$q_t^b b_{t+1} - \phi R_t\left(w_t L_t + p_t v_t\right) \geq -\kappa q_t k_{t+1}$$

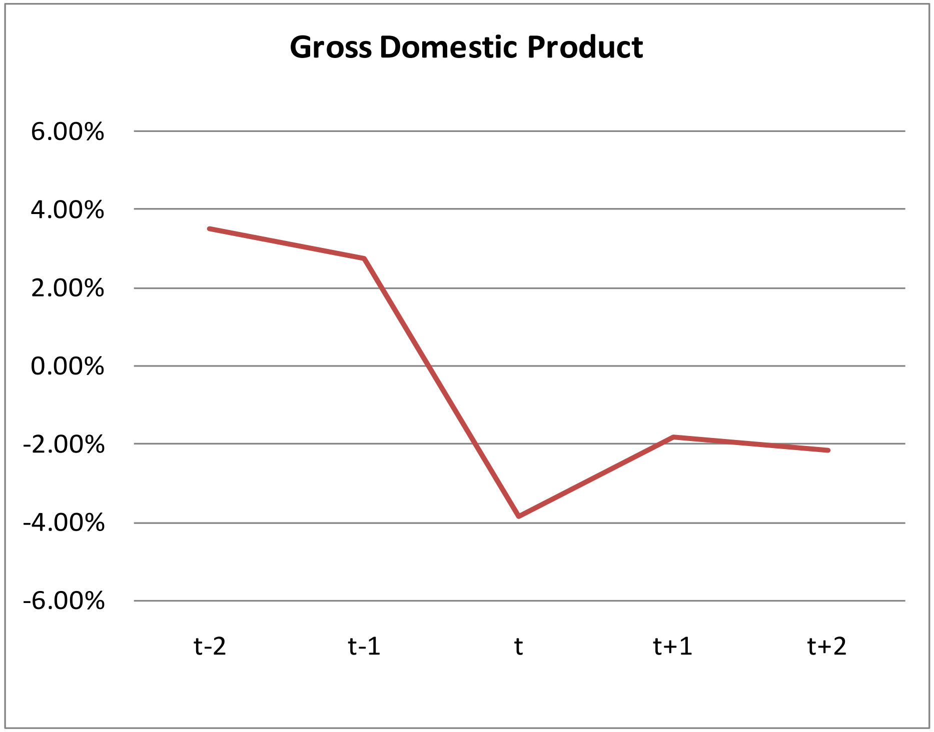
Current account reversals

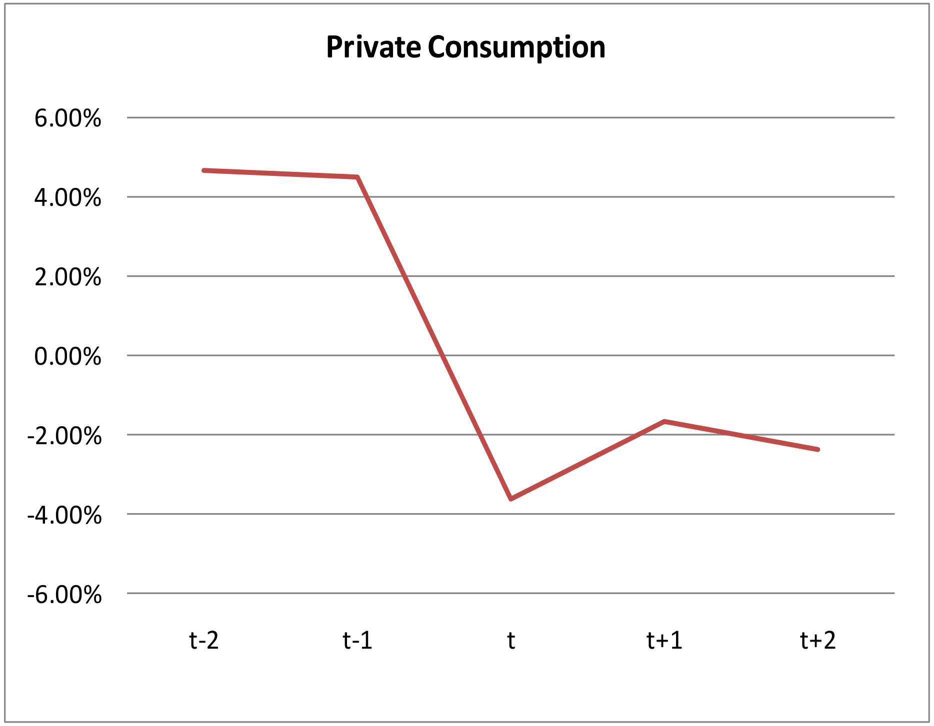
(Sudden Stop events from Calvo et al. (2006), 1970-2004, deviations from HP trends)



Output and Consumption during Sudden Stops

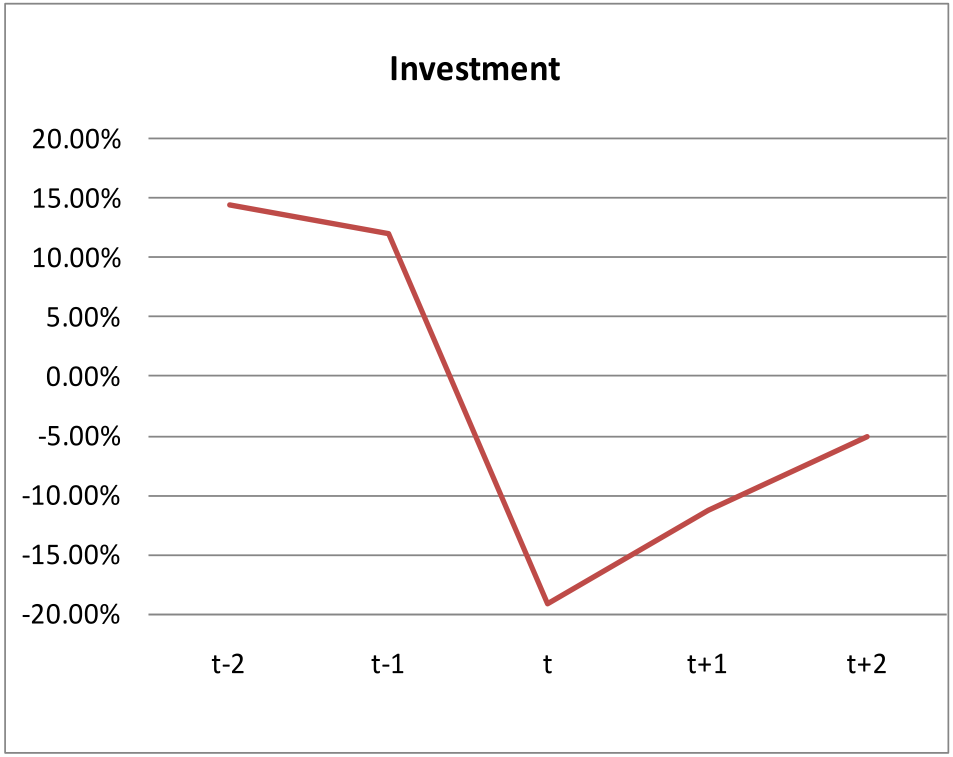
(Sudden Stop events from Calvo et al. (2006), 1970-2004, deviations from HP trends)

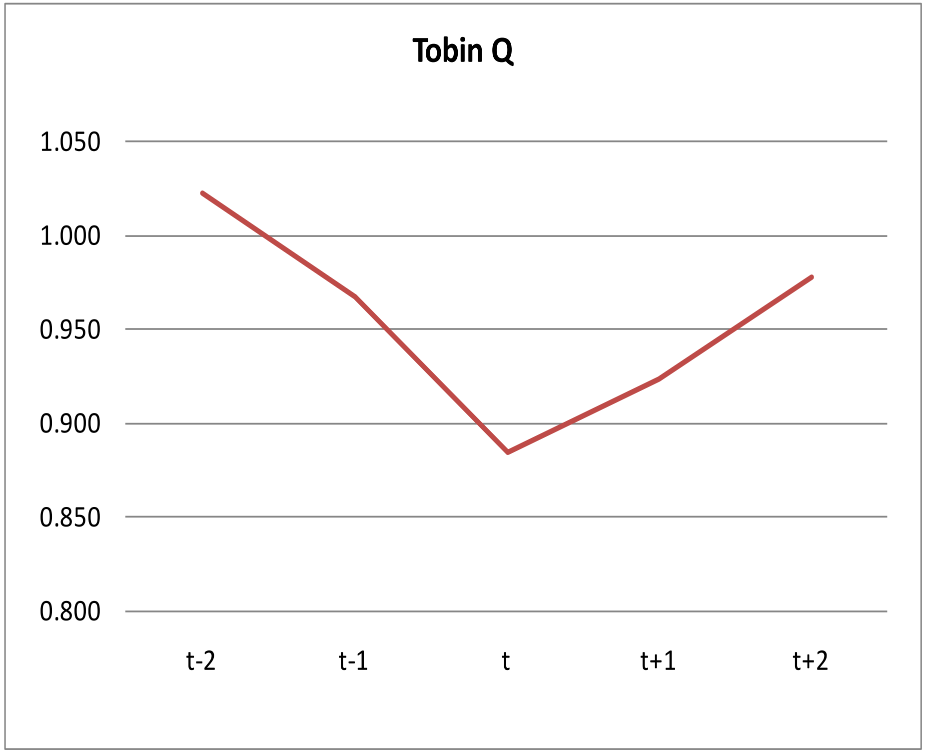




Investment and Tobin's Q during Sudden Stops

(Sudden Stop events from Calvo et al. (2006), 1970-2004, deviations from HP trends)





Main findings

- Long-run business cycle moments unaffected by credit constraints
  - Financial crises nested with normal cycles
  - Prec. saving reduces prob. of crises ($\kappa = 0.2$ calibrated to match actual frequency of SS events)
- Constraint binds in high leverage states, reached with positive prob., and in these states *typical* shocks cause financial crises
  - Model matches output, consumption, investment and net exports
  - Expansions precede crises, slow recovery in the aftermath
  - Collapse is asset prices is smaller than in data
- Large amplification & asymmetry
  - Larger than Kocherlakota's (00) due to strong debt-deflation feedback
- WK crucial for initial drops in output & factor demands
  - Along with imported inputs generates downward bias in Solow residual
- Exogenous credit constraint yields smaller effects

Solving with *FiPIt*

- Mendoza (10) solved quasi planning prob. using VFI
- Mendoza & Villalvazo (20) solved using *FiPIt*
- Removed endogenous discount factor for simplicity
- No need for nonlinear solver in Euler eqs.
- Standard bi-linear interpolation
- Matlab codes on standard desktop solve RBC in 45 seconds, SS in 75 seconds (50 without wk. capital).
- Since it is an Euler eqn's method, it is suitable for adding distortions (e.g. policy analysis)

Model for *FiPIt* solution

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\frac{(c_t-\frac{L_t^{\omega}}{\omega})^{1-\sigma}}{1-\sigma}\right]$$

$$c_t(1+\tau)+k_{t+1}-(1-\delta)k_t+\frac{a}{2}\frac{(k_{t+1}-k_t)^2}{k_t}=$$

$$A_tF(k_t,L_t,v_t)-p_tv_t-\phi(R_t-1)(w_tL_t+p_tv_t)-q_t^bb_{t+1}+b_t$$

$$q_t^bb_{t+1}-\phi R_t(w_tL_t+p_tv_t)\geq-\kappa q_tk_{t+1}$$

FiPIt algorithm summary

1. Start iteration *j* with three conjectured functions:

$$\hat{q}_j(b,k,s) \qquad \hat{B}_j(b,k,s) \equiv \hat{b}'_j(b,k,s) \qquad \hat{\tilde{\mu}}_j(b,k,s) \equiv \mu_j(b,k,s)/\lambda_j(b,k,s)$$

2. Optimality conditions imply decision rules for $K_j(b,k,s)$, $i_j(b,k,s)$, $v_j(b,k,s)$, $L_j(b,k,s)$, $y_j(b,k,s)$ and $c_j(b,k,s)$

3. Assume $\hat{\tilde{\mu}}_{j+1}(b,k,s) = 0$, opt. conditions yield new $v_{j+1}(.)$, $L_{j+1}(.)$, $y_{j+1}(.)$, then solve *directly* $c_{j+1}(.)$ using bonds Euler eq.:

bi-linear Interp.

$$c_{j+1}(b,k,s) = \left\{ \beta R E \left[\left(c_j(\hat{B}_j(b,k,s), K_j(b,k,s), s') - \frac{L_j(\hat{B}_j(b,k,s), K_j(b,k,s), s')^{\omega}}{\omega} \right)^{-\sigma} \right] \right\}^{-\frac{1}{\sigma}} + \frac{L_{j+1}(b,k,s)^{\omega}}{\omega}$$

4. New $B_{j+1}(b,k,s)$ follows then from resource constraint

5. Evaluate if credit constraint really doesn't bind. If it doesn't keep results, if it does discard them

FiPIt algorithm contn'd

6. If constraint binds, dec. rules solve this nonlinear system, which reduces to one non-linear eq. (linear if we don't have working capital in LTV constraint!):

$$v(\tilde{\mu}) = \left\{ \frac{Ak^{\gamma}\eta^{\frac{\omega-\alpha}{\omega}} \frac{\alpha}{1+\tau}^{\frac{\alpha}{\omega}}}{p^{\frac{\omega-\alpha}{\omega}}\left[1+\phi(R-1)+\tilde{\mu}\phi R\right]} \right\}^{\frac{\omega}{\omega(1-\eta)-\alpha}}$$

$$L(\tilde{\mu}) = \left\{ \frac{\alpha}{\eta(1+\tau)} p v(\tilde{\mu}) \right\}^{\frac{1}{\omega}}$$

$$\frac{B(\tilde{\mu})}{R} = -\kappa \hat{q}_j K_j + \phi R p v(\tilde{\mu}) \left[1+\frac{\alpha}{\eta}\right]$$

$$(1+\tau)c(\tilde{\mu}) = y(\tilde{\mu}) - pv(\tilde{\mu}) - \phi(R-1)pv(\tilde{\mu})\left[1+\frac{\alpha}{\eta}\right] - \tilde{i}_j - \frac{B(\tilde{\mu})}{R} + b$$

$$\tilde{\mu}_{j+1}(b,k,s) = 1 - \frac{\beta R E\left[\left(c_j(\hat{B}_j(b,k,s), K_j(b,k,s), s') - \frac{L_j(\hat{B}_j(b,k,s), K_j(b,k,s), s')^{\omega}}{\omega}\right)^{-\sigma}\right]}{\left(c(\tilde{\mu}_{j+1}(b,k,s)) - \frac{L(\tilde{\mu}_{j+1}(b,k,s))^{\omega}}{\omega}\right)^{-\sigma}}$$

FiPIt algorithm contn'd

7. Once j+1 dec. rules are solved for all the state space, solve *directly* for new pricing function using capital Euler eq.:

$$q_{j+1}(b,k,s)$$
$$= \frac{\beta E_t\left[\left(c_{j+1}\left(B_{j+1}(\cdot),K_j(\cdot),s'\right)-\frac{L_{j+1}(B_{j+1}(\cdot),K_j(\cdot),s')^{\omega}}{\omega}\right)^{-\sigma}\left[d'\left(B_{j+1}(\cdot),K_j(\cdot),s'\right)\right)+\hat{q}_j\left(B_{j+1}(\cdot),K_j(\cdot),s'\right)\right]\right]}{\left(c_{j+1}(\cdot)-\frac{L_{j+1}(\cdot)^{\omega}}{\omega}\right)^{-\sigma}\left(1-\kappa\tilde{\mu}_{j+1}(\cdot)\right)}$$

8. Evaluate convergence:

$$|q_{j+1}(b,k,s)-\hat{q}_j(b,k,s)|\leq \varepsilon^f \qquad |B_{j+1}(b,k,s)-\hat{B}_j(b,k,s)|\leq \varepsilon^f$$

$$|\tilde{\mu}_{j+1}(b,k,s)-\hat{\tilde{\mu}}_j(b,k,s)|\leq \varepsilon^f$$

7. If convergence fails, update conjectures & return to Step 1.

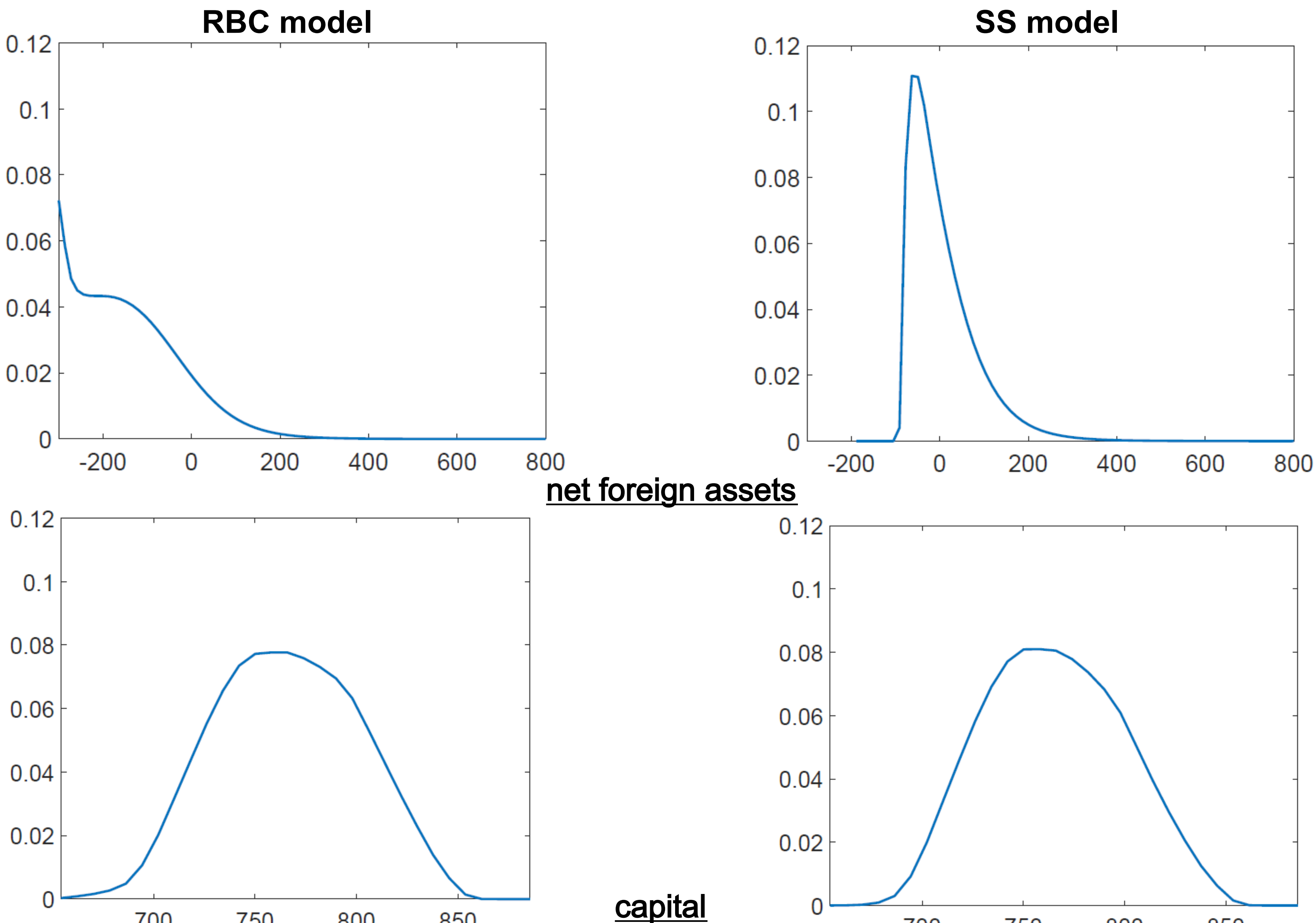
$$\hat{x}_{j+1}(b,k,s)=(1-\rho^x)\hat{x}_j(b,k,s)+\rho^x x_{j+1}(b,k,s)$$

- Use $0<\rho^x<1$ $(\rho^x>1)$ if not converging (converging slowly)

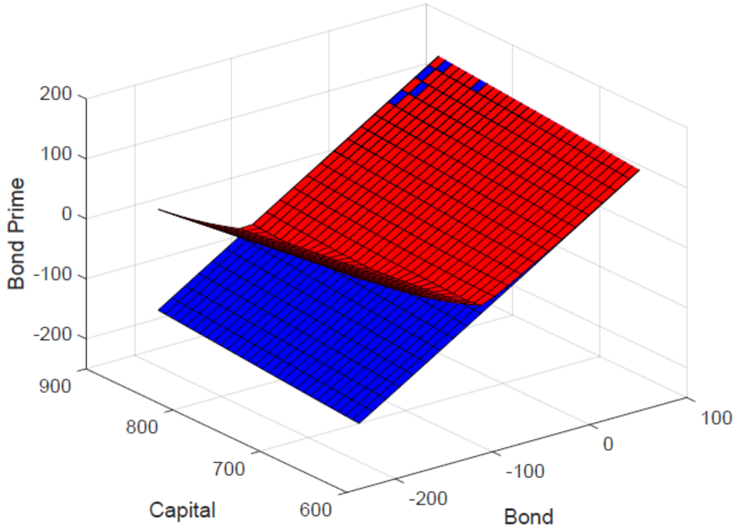
Calibration

Paramaters set with ratios from data and deterministic steady state conditions		
α	0.592	labor share set to yield 0.66 share in GDP as $\alpha/(1-\eta)$
β	0.306	capital share set to yield 0.33 share in GDP as $\beta/(1-\eta)$
δ	0.088	depreciation rate from perpetual inventories method
R	1.0857	implied by s.s.optimal investment rule
w	1.846	regression estimate using labor supply optimality condition
γ	0.0166	implied by s.s. consumption Euler eq.
b/gdp	-0.86	implied by s.s. budget constraint
Average ratios from Mexican data (1993-2005)		
$\eta = pv/y$	0.102	imported inputs/gross output ratio
k/y	1.758	capital/gross output ratio
pv/gdp	0.114	imported inputs/gdp ratio
gdp/y	0.896	gdp/gross output ratio
c/gdp	0.65	consumption/gdp ratio
g/gdp	0.110	gov. purchases/gdp ratio
i/gdp	0.172	investment/gdp ratio
g/c	0.168	ratio of public to private consumption
Parameters set with SMM		
a	2.75	targeted to match ratio of s.d. of investment to s.d. of gdp
ϕ	0.2579	targeted to yield a mean working capital/gdp ratio of 0.2

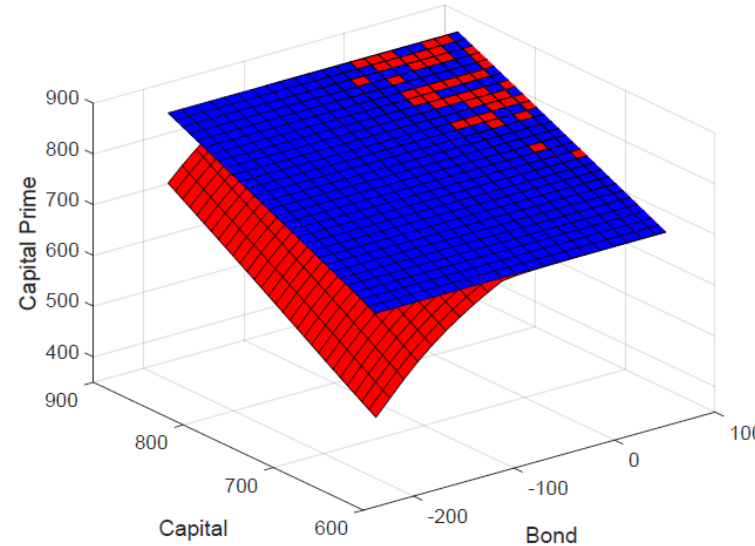
FiPIt limiting distributions



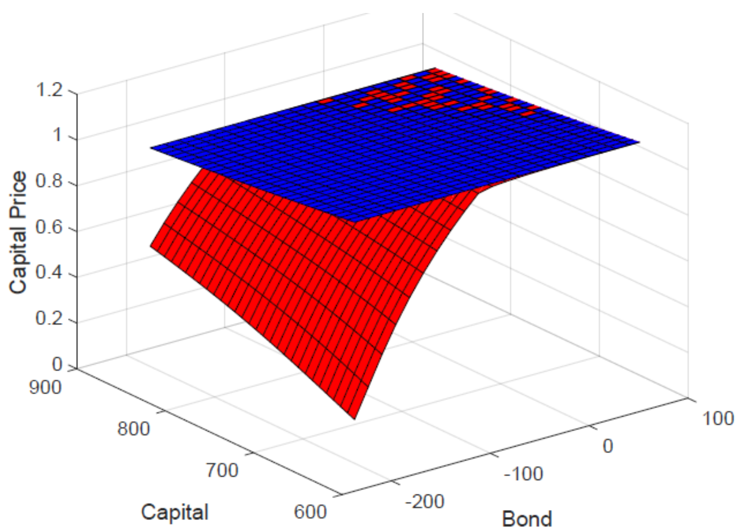
FiPIt decision rules, pricing function & multiplier



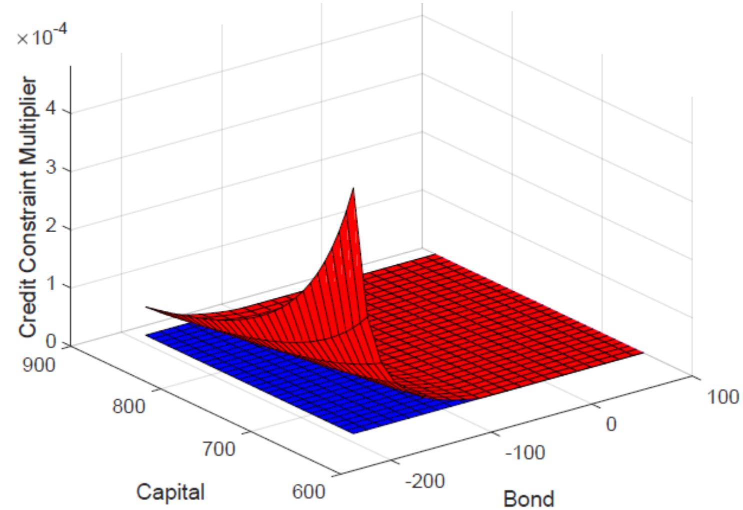
bonds



capital



capital price

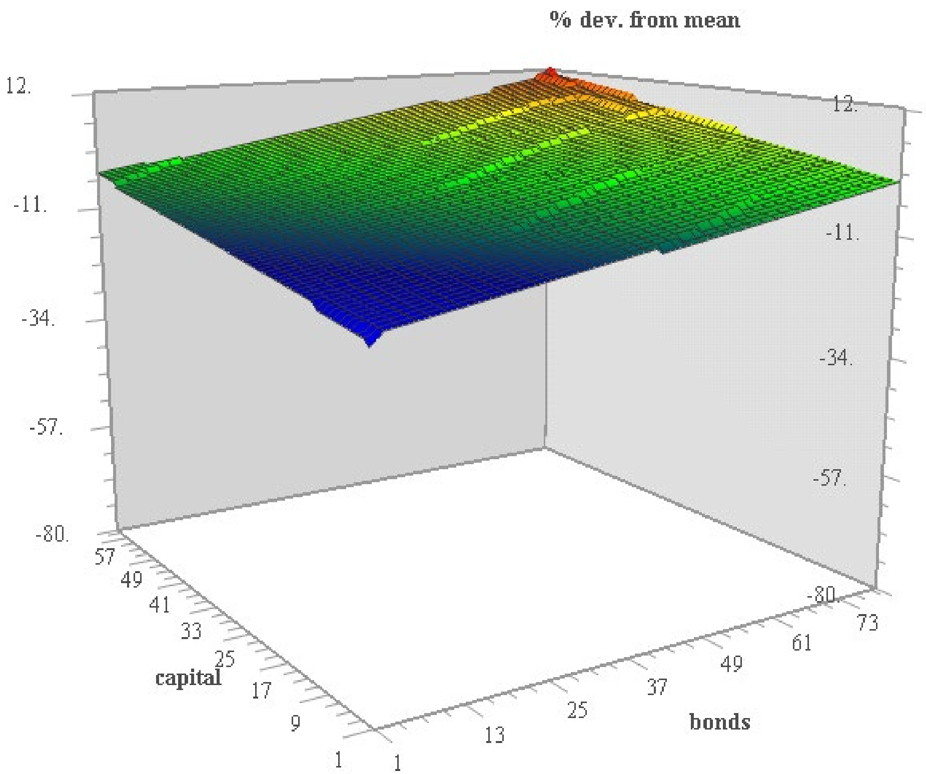


multiplier

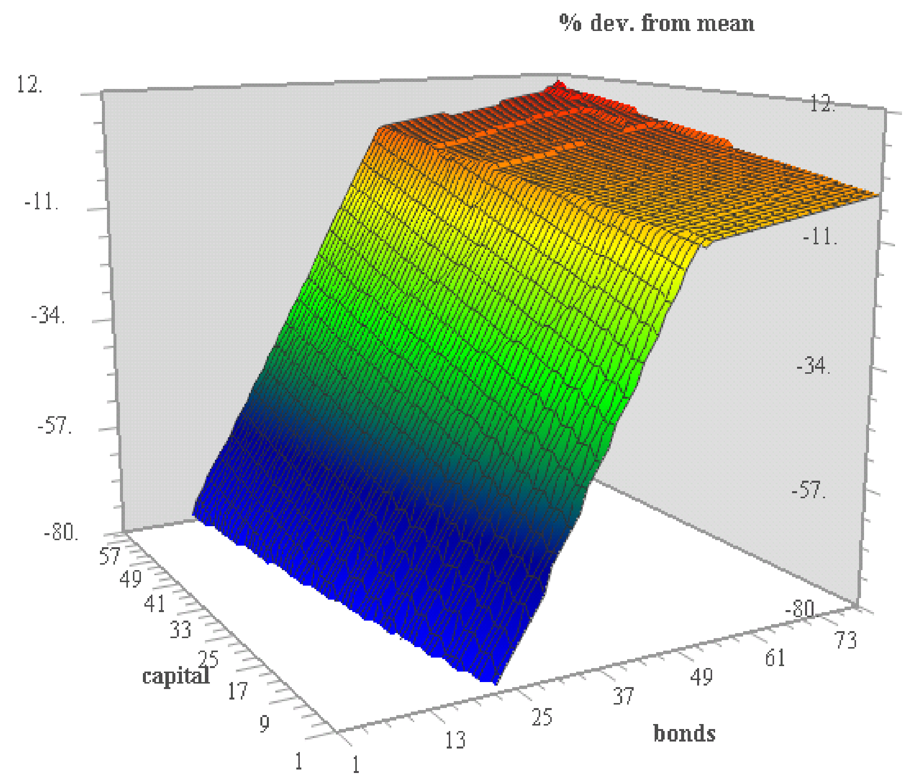
RBC model, SS model

Universe of consumption impact effects

(percent deviations from mean in response to 1sd shocks to TFP, R and p^v)



Perfect credit markets



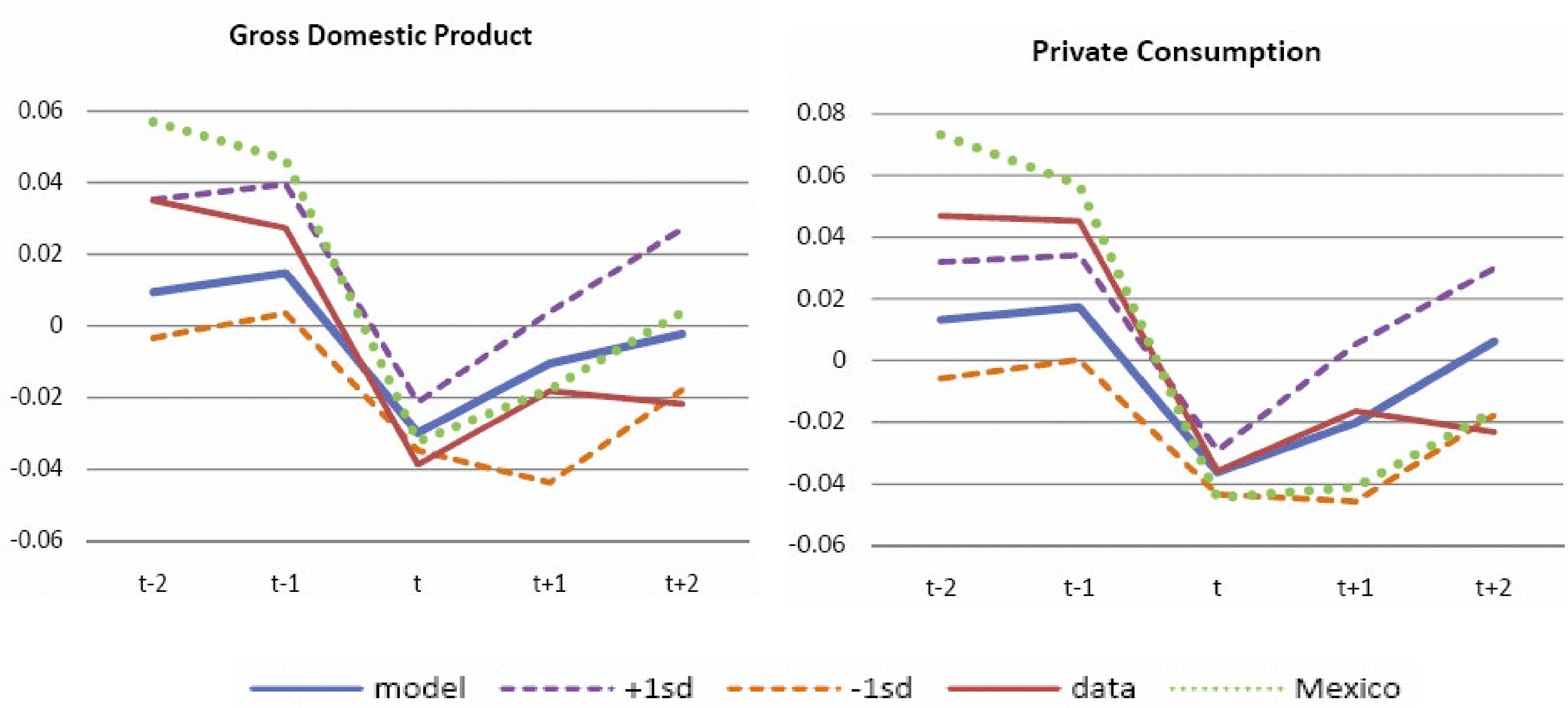
Economy with collateral constraint

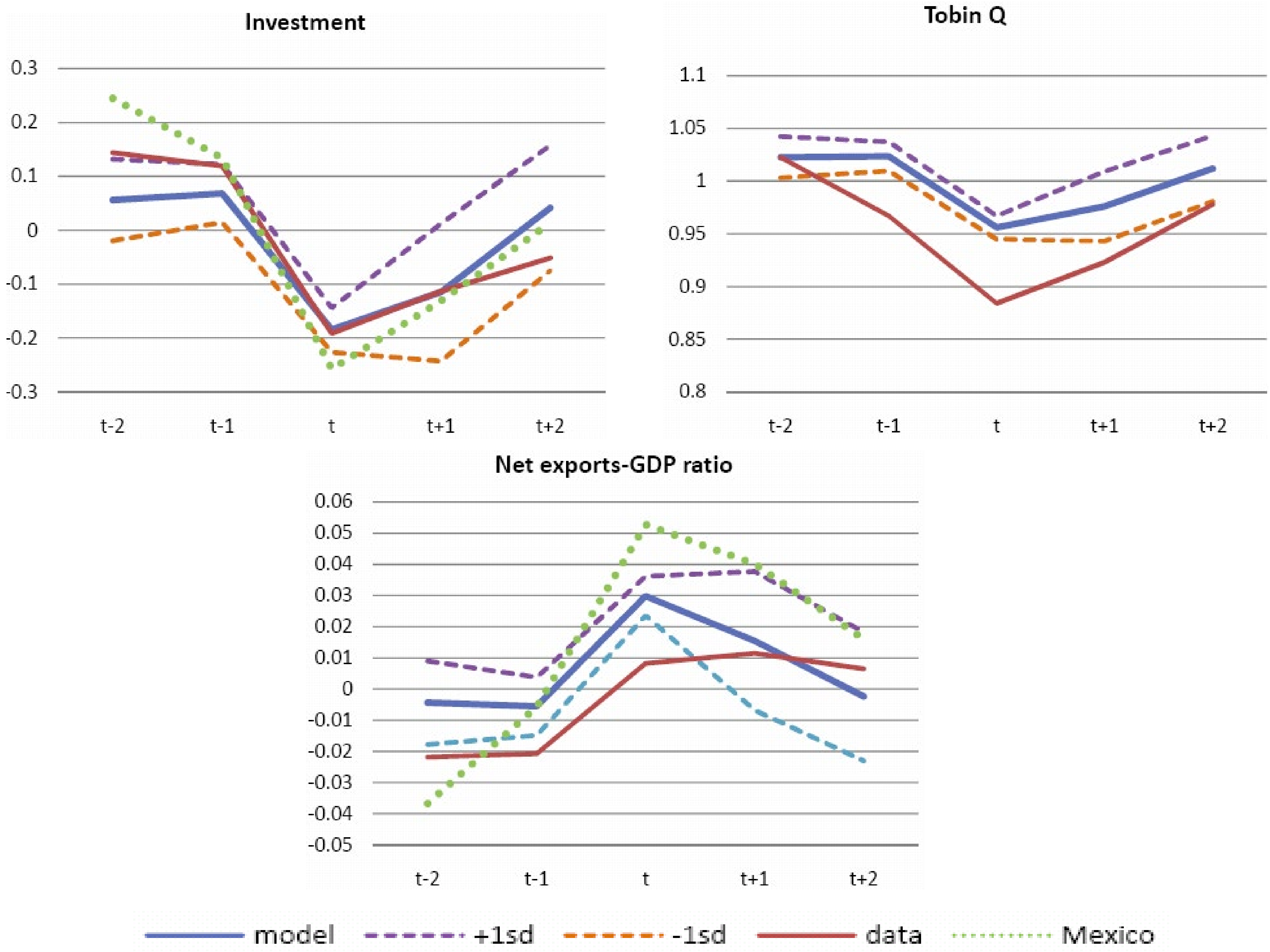
Amplification & Asymmetry in Crises

(mean excess responses relative to frictionless economy in percent of frictionless averages)

	(1) baseline economy κ=0.20		(2) lower collateral coefficient κ=0.30		(3) higher collateral coefficient κ=0.15		(4) zero net exports threshold		(5) no working capital	
	S.S. states	non S.S. states	S.S. states	non S.S. states	S.S. states	non S.S. states	S.S states	non S.S states	S.S states	non S.S states
gdp	-1.13	-0.11	-1.18	-0.06	-1.21	-0.14	-0.86	-0.06	0.00	0.00
c	-3.25	-0.31	-3.17	-0.14	-3.15	-0.42	-2.12	-0.23	-1.54	-0.34
i	-11.84	-0.61	-10.73	-0.18	-12.35	-0.91	-7.48	-0.30	-9.71	-1.25
q	-2.88	-0.15	-2.64	-0.04	-2.99	-0.22	-1.81	-0.07	-2.53	-0.31
nx/gdp	3.56	0.25	3.32	0.08	3.47	0.34	2.13	0.17	3.11	0.49
b/gdp	3.57	0.25	3.00	0.06	3.60	0.36	2.11	0.18	3.31	0.53
lev. ratio	1.31	0.12	0.89	0.04	1.47	0.18	0.83	0.09	0.90	0.17
L	-1.71	-0.16	-1.79	-0.09	-1.83	-0.22	-1.29	-0.10	0.00	0.00
v	-3.10	-0.29	-3.21	-0.16	-3.31	-0.40	-2.36	-0.18	0.00	0.00
w. cap.	-3.12	-0.29	-3.25	-0.16	-3.34	-0.40	-2.37	-0.18	na	na
prob. of SS events	3.32%		1.07%		3.92%		9.54%		0.07%	
b/gdp *in SS events*	-0.21		-0.44		-0.17		-0.20		-0.40	

Financial crises events: Model v. data




Investment
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
t-2
t-1
t
t+1
t+2
Tobin Q
1.1
1.05
1
0.95
0.9
0.85
0.8
t-2
t-1
t
t+1
t+2
Net exports-GDP ratio
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
t-2
t-1
t
t+1
t+2
model
+1sd
-1sd
data
Mexico

Local methods for SS models: OccBin, DynareOBC

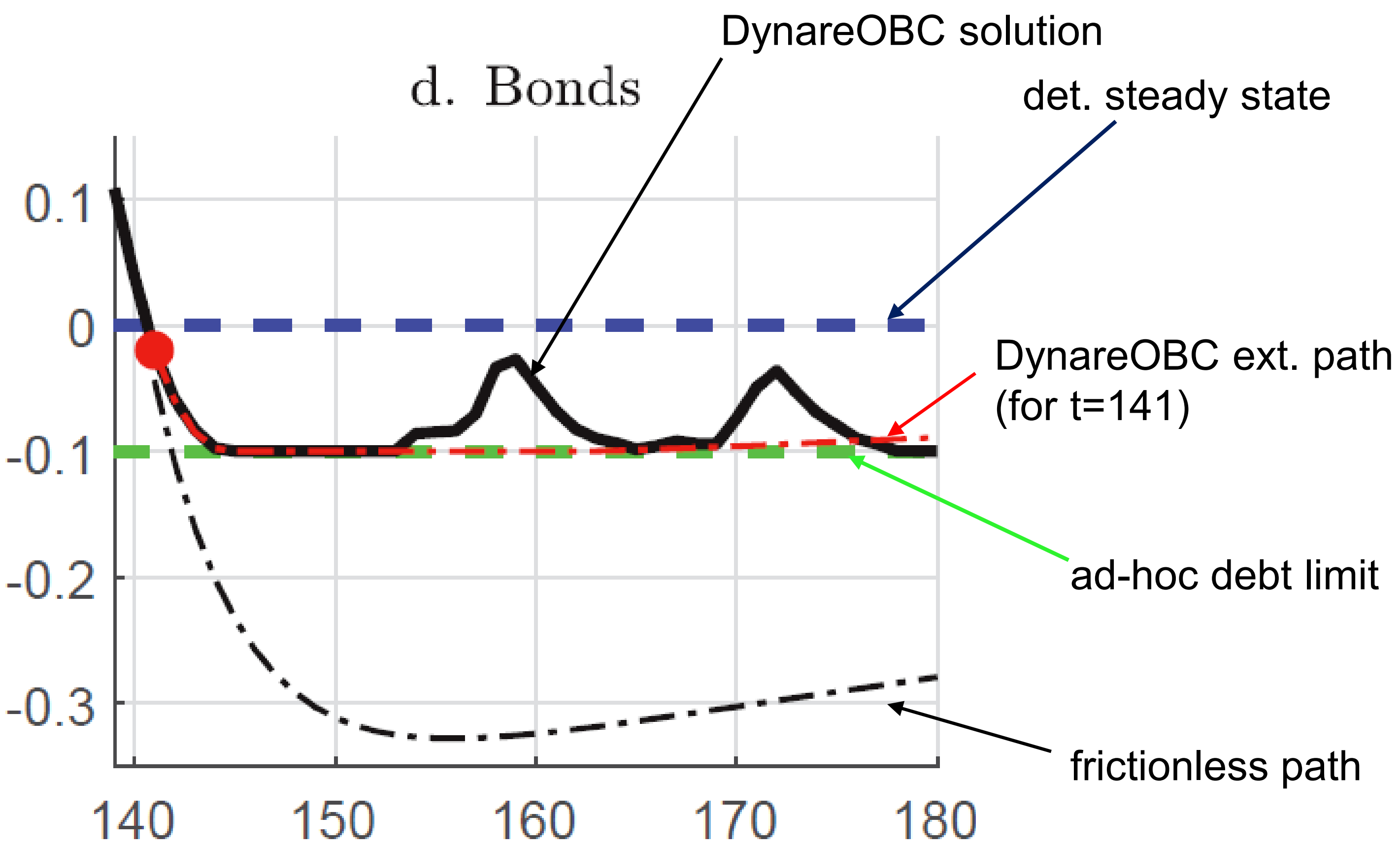
- DynareOBC (Holden 2016): constraint treated as future "endogenous news shock" along perfect foresight paths (conditional on date-t states and det. evolution of shocks)
- If constraint is not (is) binding at det. steady state, it uses news shocks to solve for constrained (unconstrained) periods along those paths (mixed integer linear programming prob.)
- If constraint does not bind at st. st., when agents anticipate constraint binds at some t+j, this is "news" that NFA will be higher than otherwise
- Akin to not having constraint, but when agents are on a path requiring more debt than allowed, news shocks hit to make them borrow what is allowed and less before that happens
- Guaranteed to converge in "finite time," same results as OccBin

Mechanics of DynareOBC

- Output is a time-series simulation linking date-*t* values of perfect-foresight eq. paths conditional on (k_t,b_t,s_t)
- Each path obtained using extended path algorithm (of 1st or higher order) that traces dynamics T periods ahead of *t*, with shocks following deterministic VAR dynamics.
  - Path starting at *t* determines (k_{t+1},b_{t+1}) and these together with s_t and eq. conditions determine date-*t* endogenous variables.
  - Discard the rest and repeat at *t+1*
- Efficiency hinges on:
  1. T large enough so that for *t*>T no news shocks are needed (e.g. if constraint binds at det ss., constraint always binds for *t*>T)
  2. For each path requiring news shocks, the algorithm needs to find the “correct” sequence of news shocks
  3. Long enough simulation for long-run moments to converge

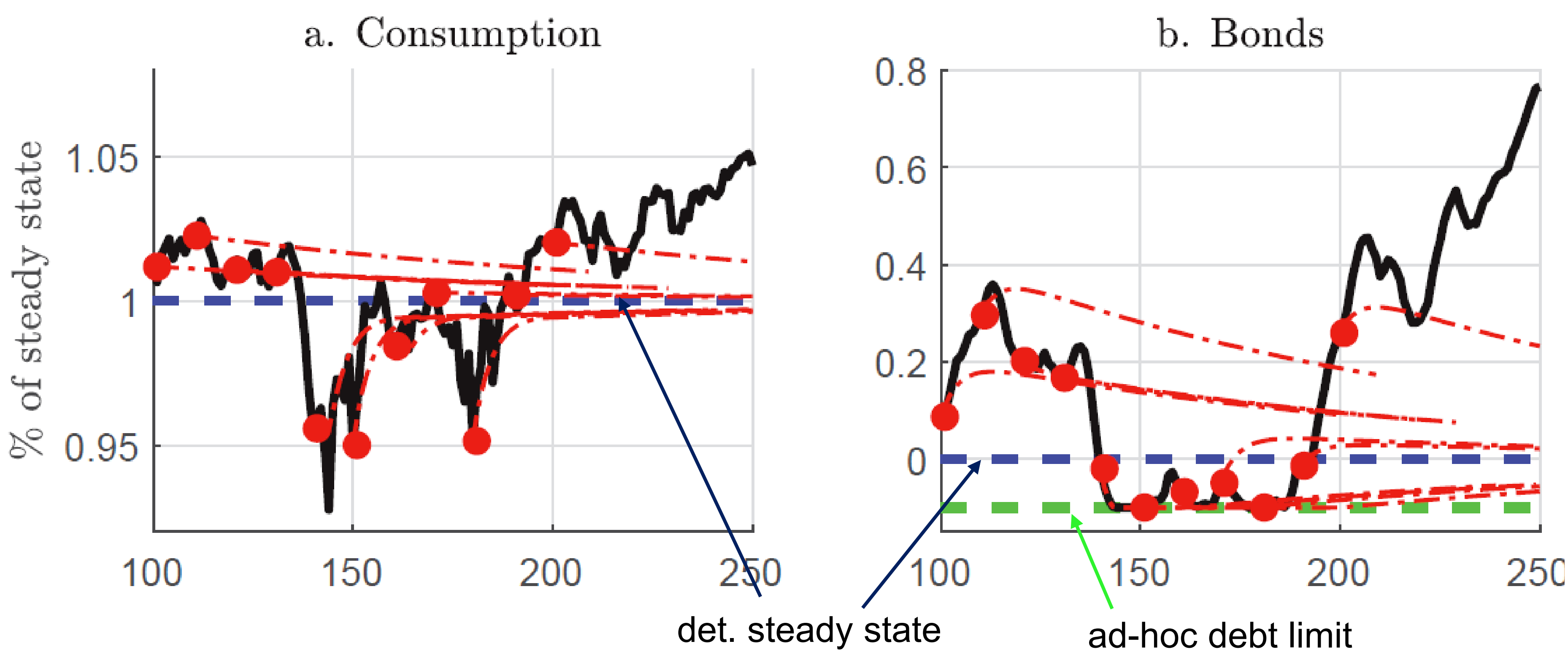
Example path of bonds in DynareOBC solution

(endowment SOE model w. ad-hoc debt limit)



Note: Solution for *t*=141 (red dot) and associated extended path (dashed red curve). Dashed black curve shows solution without constraint/news shocks.

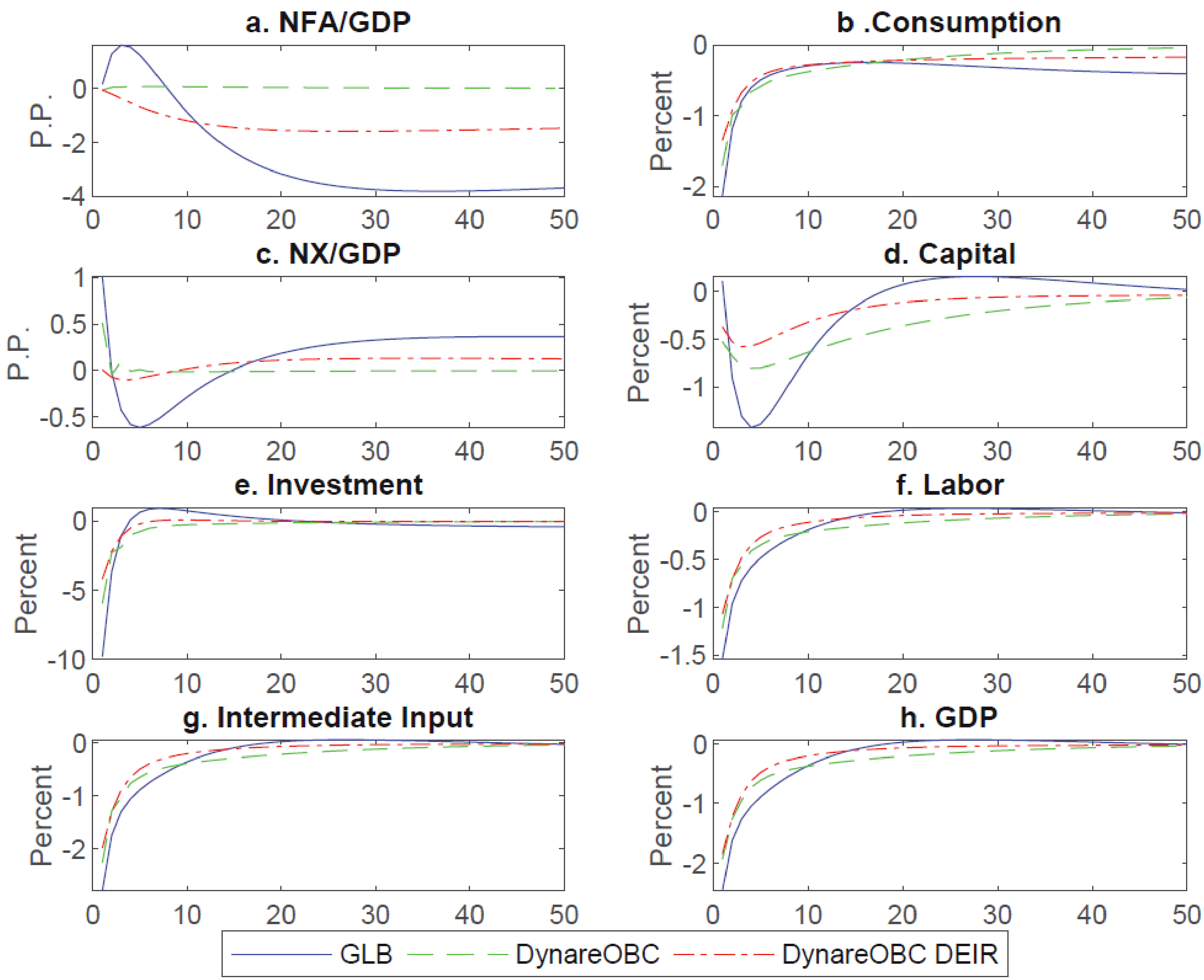
DyanreOBC solution and sample paths



Note: 11 extended paths (red dashed lines) that yield DynareOBC solutions (red dots) along DynareOBC time-series simulation (black curve). 4 paths hit the constraint and need news shocks, 7 do not.

FiPIt (Global) solution v. DynareOBC for SS model

(IRFs to 1sd negative TFP shock)



FiPIt v. DynareOBC when the constraint binds

- Shadow interest premium:

$$SIP_t = \frac{R_t \mu_t (1+\tau)}{u'(t) - \mu_t (1+\tau)}$$

- Equity and risk premia:

$$EP_t = (1-\kappa) SIP_t + RP_t, \qquad RP_t \equiv -\frac{COV_t[u'(t+1), R^q_{t+1}]}{E_t[u'(t+1)]}$$

- 1st order-DynareOBC is far from GLB solution when constraint binds because it ignores risk (*RP*=0) and underestimates frequency, magnitude and macro effects of credit constraint.

- It also underestimates prec. savings caused by the constraint (-10 v. 1.5% mean NFA/GDP) and prob. of hitting it (52 v. 2.6%)

- It is also of comparable speed as *FiPIt*

FiPIt v. DynareOBC when the constraint binds

	$\log(\mu)$		Financial Premia *means in each quintile of μ*				Macro variables *means of deviations from long-run averages in each quintile of μ*					
	upper limit	mean	SIP	EP	$(1-\kappa)SIP$	RP	c	NX/GDP	i	GDP	L	v
Panel a. GLB												
Quintiles of μ												
First	-6.563	-9.302	0.32	0.37	0.26	0.10	-2.76	1.98	-1.76	-0.60	-0.26	0.35
Second	-6.320	-8.635	1.07	0.96	0.85	0.11	-2.17	1.37	2.70	0.08	0.15	-1.25
Third	-6.088	-8.516	1.82	1.56	1.46	0.10	-3.80	2.30	-3.00	-1.35	-0.82	-1.29
Fourth	-5.843	-8.235	2.98	2.48	2.38	0.09	-4.72	2.58	-5.46	-2.26	-1.42	-3.35
Fifth	-3.374	-7.920	6.59	5.38	5.27	0.10	-4.86	5.10	-13.45	-1.21	-1.37	-2.98
Overall mean		-7.627	2.59	2.17	2.07	0.10	-3.64	2.64	-4.05	-1.04	-0.73	-1.78
Overall median		-6.198	1.79	1.52	1.43	0.11	-3.22	1.60	-1.64	-1.02	-0.57	-2.15
			Ex-post Sharpe ratio = 1.16									
Panel b. DynareOBC-$BetaR < 1$												
Quintiles of μ												
First	-9.000	-9.155	0.00	0.00	0.00	0.00	-0.78	0.73	-3.17	-0.40	-0.30	-0.53
Second	-8.523	-8.638	0.01	0.01	0.01	0.00	-1.74	1.38	-6.36	-1.10	-0.77	-1.58
Third	-8.155	-8.319	0.02	0.01	0.01	0.00	-3.23	2.33	-11.28	-2.24	-1.52	-3.13
Fourth	-6.295	-6.707	0.66	0.53	0.53	0.00	-2.02	1.24	-4.04	-1.13	-0.68	-1.54
Fifth	-5.523	-6.005	3.32	2.65	2.65	0.00	-1.85	0.38	-1.35	-1.38	-0.81	-1.92
Overall mean		-6.623	0.800	0.64	0.64	0.00	-1.92	1.21	-5.24	-1.25	-0.82	-1.74
Overall median		-8.337	0.015	0.01	0.01	0.00	-1.87	0.93	-4.71	-1.23	-0.81	-1.74
			Ex-post Sharpe ratio = 0.25									

A model with foreign asset trading

(*Mendoza & Smith, JIE 2006)*

- Two-agent equilibrium asset pricing model
  - Margin constraint: $b_{t+1} \geq -\kappa q_t \alpha_{t+1} k$ and short-selling constraint $\alpha_{t+1} \geq \chi$
  - Endogenous supply-side but independent of financial frictions
    - GHH utility $u(c\text{-}G(L))$: $MRS(c,L)$ independent of c
    - Competitive firms, no capital accumulation: $e_t^A F(L_t,K)$
  - Foreign securities firms with trading costs: $q_t \left(\frac{a}{2}\right)\left(\alpha^*_{t+1} - \alpha^*_t + \theta\right)^2$
  - Foreign traders' demand: $\alpha^*_{t+1} - \alpha^*_t = 1/a \left[q^f_t / q_t - 1\right] - \theta$
- SS are endogenous response to 1sd. TFP shocks:
  - Requires high enough leverage $(-b_t / q_t \alpha_t k)$, AND liquid asset market
  - $ca,\ c$ close to actual SS, large fall in q needs high elasticity ($1/a$)
  - Long-run prob. of binding margin constraint = 2.5% (with $1/a$ = 0.5)
  - Trading costs in percent of returns in line with empirical evidence

Households and foreign traders

- Households preferences and constraints :

$$U = E\left[\sum_{t=0}^{\infty} \exp\left\{-\sum_{\tau=0}^{t-1} v(c_\tau - G(L_\tau))\right\} u(c_t - G(L_t))\right]$$

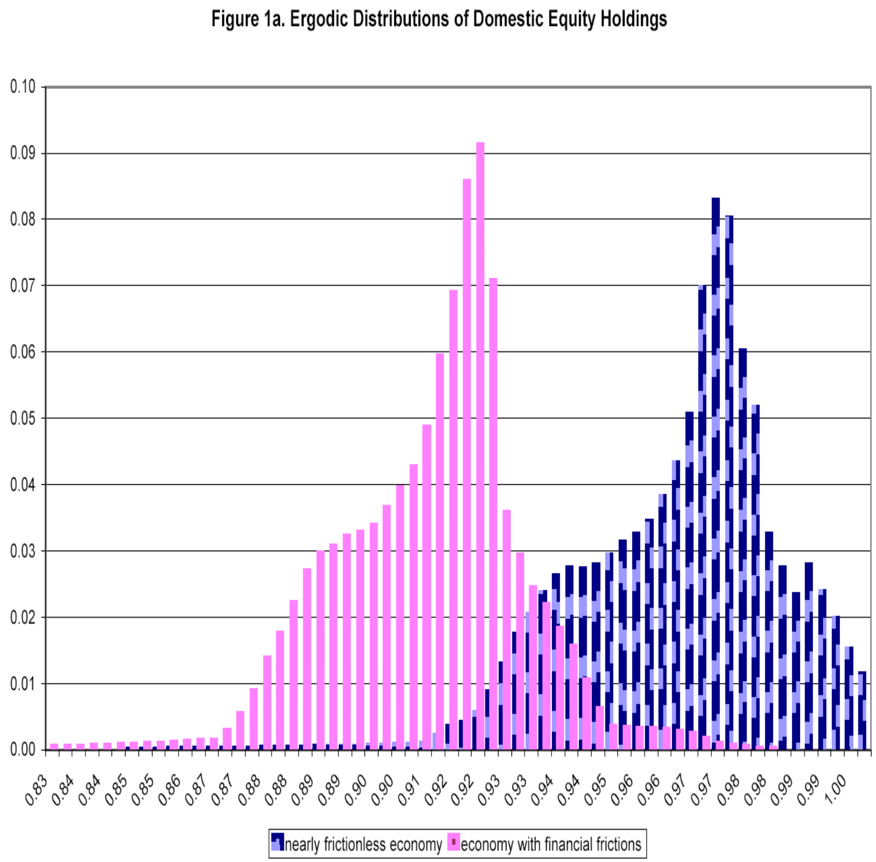
$$c_t = \alpha_t K d_t + w_t L_t + q_t(\alpha_t - \alpha_{t+1})K - b_{t+1} + b_t R$$

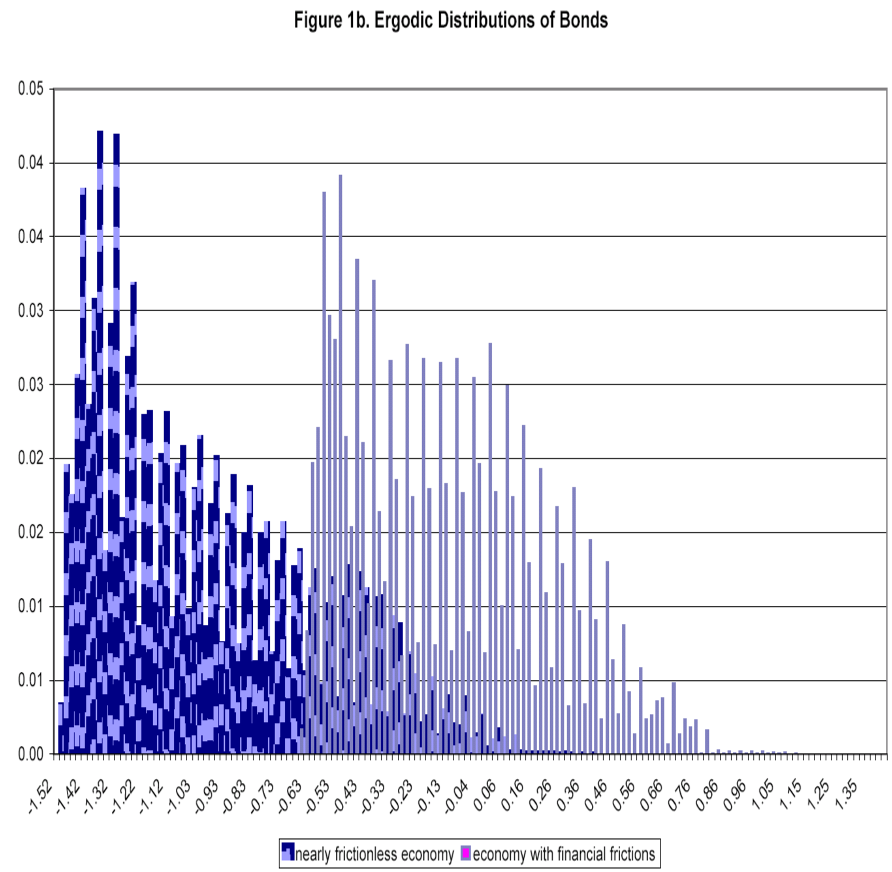
$$b_{t+1} \geq -\kappa q_t \alpha_{t+1} k \qquad \alpha_{t+1} \geq \chi$$

- Value of foreign traders' firms per unit of capital:

$$D/K = E_0\left[\sum_{t=0}^{\infty} M_t^* \left(\alpha_t^*(d_t + q_t) - q_t \alpha_{t+1}^* - q_t \left(\frac{a}{2}\right)(\alpha_{t+1}^* - \alpha_t^* + \theta)^2\right)\right]$$

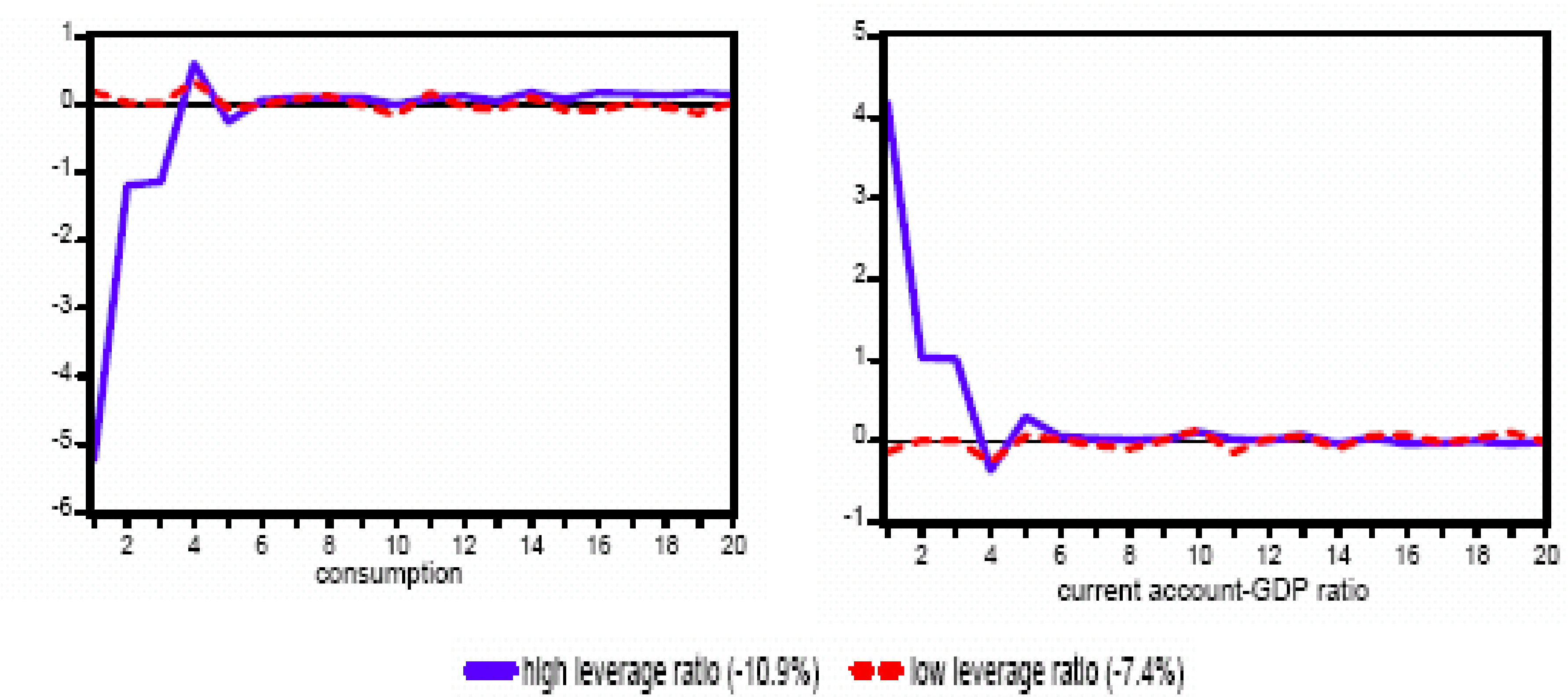
Long-run distributions of equity & bonds





Crisis responses at high and low leverage ratios

(differences in forecast functions in response to 1sd , negative TFP shock)

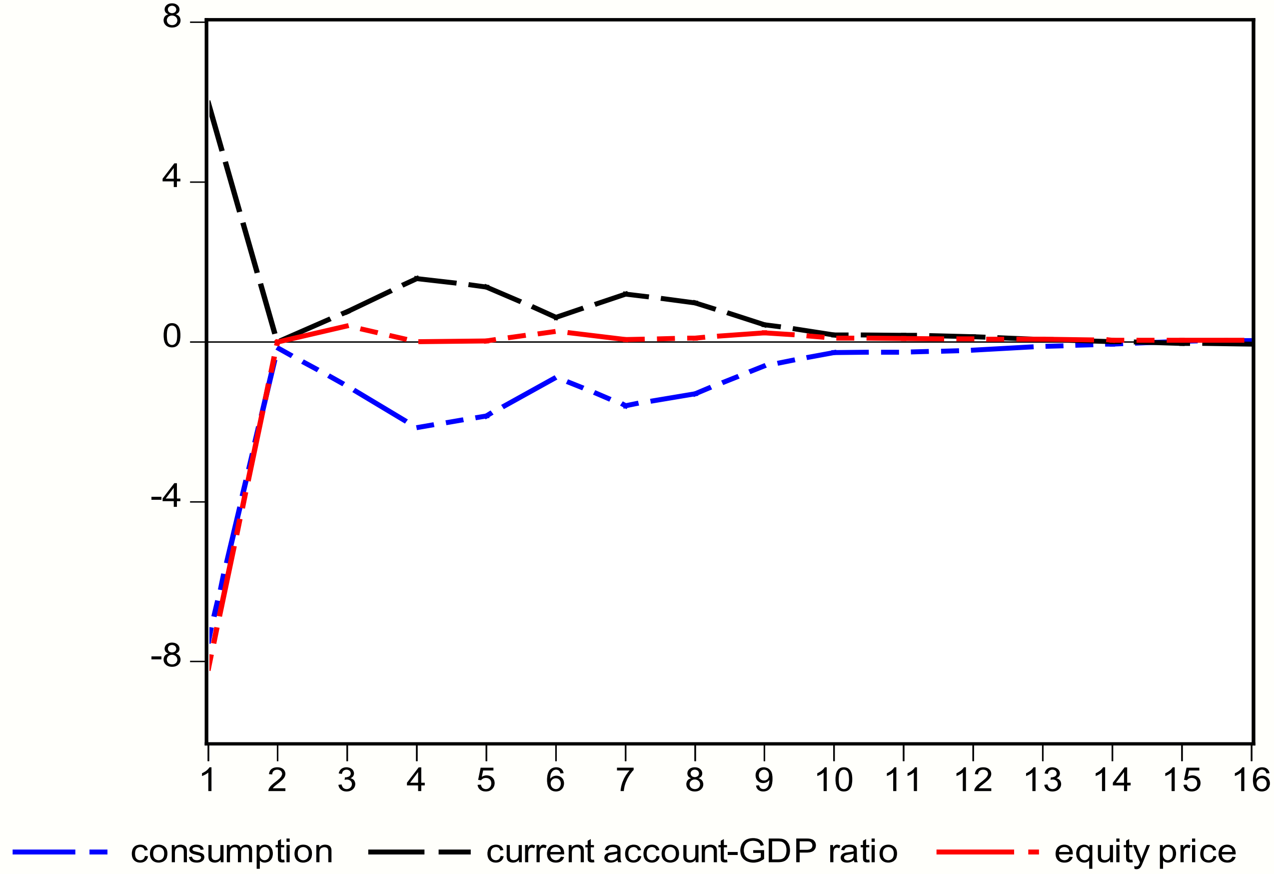


High leverage state: α=0.806, b=-1.481, b/qα=-10.9%

Low leverage state: α=0.806, b=-1.01, b/qα=-7.4%

Crisis responses: low foreign demand elasticity (½)

Figure 2. Sudden Stop Dynamics in Mendoza-Smith Model with Foreign Demand Elasticity of 1/2
(percent deviations relative to economy with perfect credit markets)



Note: Forecast functions conditional on a negative, one-standard-deviation productivity shock and a leverage ratio of 12.2% at date 1 (see Mendoza and Smith (2005) for details) .

Extensions

- Durdu and Mendoza (JIE, 2006)
  - Add asset price guarantees offered by IFI to foreign traders
  - Sell at market price or at guaranteed price, financed with lump-sum taxes
  - Prevents Fisherian deflation but induces moral-hazard-like distortion on demand for domestic equity
- Mendoza and Smith (SJE, 2014)
  - Add production of NT goods with labor & imported inputs
  - Combines Fisherian effects on labor demand and dividends and on the value of assets as collateral
  - Study short- and long-run effects of financial integration
  - Overshooting in prob. of SSs and debt

Normative Implications: Macroprudential policy analysis

Review of findings from positive analysis

- Results of quantitative studies suggest Fisherian models are a reasonable platform for normative analysis:
  1. Large amplification and asymmetry in response to standard shocks to TFP, TOT, interest rates
  2. Endogenous, infrequent financial crises w. deep recessions, large CA reversals and RER collapses
  3. Crises nested within business cycles with realistic features
- DTI models: Mendoza (01, 02), Durdu et al. (09), Bianchi (11), Benigno et al. (13,16), Sch.-Grohe & Uribe (18),…
- LTV models: Durdu & Mendoza (06), Mendoza & Smith (06, 14), Mendoza (10), Mendoza & Quadrini (10), Jermann & Quadrini (12), Sch.-Grohe & Uribe (17),…

Market failure in Fisherian models

- Fisherian collateral constraints:

$$\frac{b_{t+1}}{R_t} \geq -\kappa_t f(p_t)$$

  1. DTI models: $f(p_t) = y_t^T + p_t^N y_t^N$
  2. LTV models : $f(p_t) = q_t k_{t+1}$

- Market price of collateral is determined by <u>aggregate</u> allocations: $f\left(p_t^N(C_t^T, C_t^N)\right)$, $f(q_t(C_t, C_{t+1}, \dots))$

- **Pecuniary externality**: Agents choose debt in "good times" ignoring price responses in "crisis times"

Macroprudential pecuniary externality

- Euler eq. for bond holdings in **decentralized eq.**:

$$u'(t) = \beta R_t E\left[u'(t+1)\right] + \mu_t$$

  - In normal times μ_t=0 => standard Euler equation

- But for a **constrained-eff. planner** (regulator) that internalizes the externality the Euler eq. is:

$$u'(t) = \beta R_t \mathbb{E}_t\left[u'(t) + \mu_{t+1}\kappa_{t+1}\psi^i_{t+1}\right], \qquad i = DTI, LTV$$

$$\psi^{DTI}_{t+1} = y^N_{t+1}(\partial p^N_{t+1}/\partial C^T_{t+1}), \qquad \psi^{LTV}_{t+1} = K_{t+1+j}(\partial q_{t+1}/\partial C_{t+1}), \qquad j = 0, 1$$

- **If** social MC of debt exceeds private MC, there is overborrowing in the absence of regulation

Proving the social MC of debt *is* higher

- Higher social MC of debt requires:

$$(\partial p^N_{t+1}/\partial C^T_{t+1}), (\partial q_{t+1}/\partial C_{t+1}) > 0$$

- In DTI and LTV models, both derivatives are positive because of concavity of utility:

DTI setup:

$$\frac{\partial p^N_{t+1}}{\partial C^T_{t+1}} = \frac{-p^N_{t+1} u_{c^T c^T}(t+1)}{u_{c^T}(t+1)} > 0$$

LTV setup:

$$\frac{\partial q_{t+1}}{\partial C_{t+1}} = \frac{-q_{t+1} u_{cc}(t+1)}{u_c(t+1)} > 0$$

- A large externality is implied if the model without regulation generates large price drops during crises!

Optimal Macroprudential policy

- An optimal macroprudential debt tax decentralizes the planner's allocations:

$$\tau_t = \frac{\mathbb{E}_t\left[\mu_{t+1}\kappa_{t+1}\psi^i_{t+1}\right]}{\mathbb{E}_t\left[u'(t+1)\right]} \qquad i = DTI, LTV.$$

  - $\tau_t > 0$ only if the constraint is expected to bind with some probability at t+1.

- Equivalent instruments: capital requirements, CCyB, regulatory LTV or DTI ratios.

MPP: Use & effectiveness

- **Widespread use:** Cerutti et al. (15) built MPI of 12 instruments, 120 countries. During 2000-2013, mean rose from 1 (0.6) to 2.5 (2) worldwide (in AEs), 90% of countries have at least one instrument

- **LTVs/DTIs gaining relevance**: 35% of countries; strong evidence that they hamper credit & asset prices (housing)

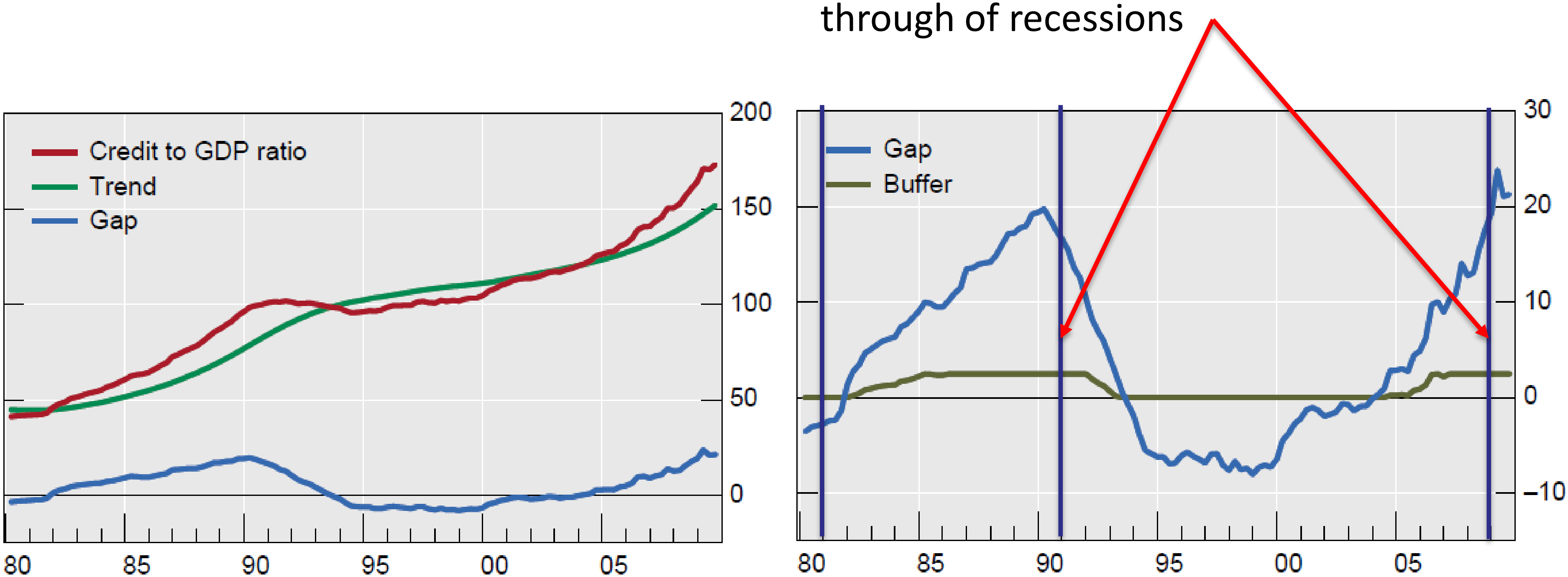
- **Mixed results for others** (Galati & Moessner (18), Araujo et al. (20)):
  1. Ambiguous results for credit expansion, no effect on contractions
  2. Cap. controls change composition of flows, some evidence of reduced leverage and gross inflows in banks but insignificant for net flows
  3. Precision-weighted, standardized average effect of *combined* MPP tools on credit is about -1% but very noisy and lack robustness

- **CCyB (Basle III):** Extra capital when credit/GDP rises 2% above HP trend, rising linearly until it reaches 10%
  - Used in 9 countries as of 2018 (e.g. Sweden, UK, Norway, HK)
  - Optimal policy *is* countercyclical, but simple rules show weak results and high sensitivity to threshold/elasticity settings!

CCyB example: the UK case

(BIS (2010) "Guidance for national authorities….")

CCyB at max in
through of recessions



Sources: National data; BIS calculations.

Trend = HP trend of credit/GDP, one-sided w. smoothing parameter at 400,000

Gap = Deviation from trend (credit cycles last 20 year!)

- Requires structural model! (classic case of Lucas critique)

Application to DTI model (complexity)

MPP with News & Global Liquidity Switches
(Bianchi, Liu & Mendoza (JIE 2016))

- Start with canonical DTI model of Sudden Stops/MPP (Mendoza (02), Durdu et al. (09), Bianchi (11)))
  1. SOE with tradables & nontradables
  2. Debt denominated in tradables, backed-up by total income
  3. Fluctuations in p^N affect borrowing capacity
- Add noisy but informative news about next-period's fundamentals (GDP of Tradables sector)
- Add regime switches in global liquidity (interest rates or borrowing capacity)
- Solve DE without policy, constrained-efficient SP problem, and optimal MPP (debt taxes)

Decentralized Equilibrium: Households

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c).$$

$$c = \left[\omega \left(c^T\right)^{-\eta} + (1-\omega)\left(c^N\right)^{-\eta}\right]^{-\frac{1}{\eta}}, \eta > 1, \omega \in (0,1).$$

$$q_t b_{t+1} + c_t^T + p_t^N c_t^N = b_t + y_t^T + p_t^N y_t^N$$

$$q_t b_{t+1} \geq -\kappa(y_t^T + p_t^N y_t^N)$$

News shocks about tradables endowment

- Signal s_t informs about y^T_{t+1}, with precision θ:

$$p(s_t = i | y^T_{t+1} = l) = \begin{cases} \theta & \text{if } i = l \\ \frac{1-\theta}{N-1} & \text{if } i \neq l \end{cases}$$

--Uninformative if $\theta = \frac{1}{N}$, perfectly informative if $\theta = 1$

- Conditional forecast probability:

$$p(y^T_{t+1} = l | s_t = i, y^T_t = j) = \frac{p(s_t = i | y^T_{t+1} = l) p(y^T_{t+1} = l | y^T_t = j)}{\sum_n p(s_t = i | y^T_{t+1} = n) p(y^T_{t+1} = n | y^T_t = j)}$$

- Joint (s, y^T) Markov transition probabilities:

$$\begin{aligned} \Pi(y^T_{t+1}, s_{t+1}, y^T_t, s_t) &\equiv p(s_{t+1} = k, y^T_{t+1} = l | s_t = i, y^T_t = j) \\ &= p(y^T_{t+1} = l | s_t = i, y^T_t = j) \sum_m \left[p(y^T_{t+2} = m | y^T_{t+1} = l) p(s_{t+1} = k | y^T_{t+2} = m) \right] \end{aligned}$$

Global liquidity regimes

- Shifts in global liquidity result in regimes of persistently high or low real interest rates

- Standard two-point regime-switching process:

1. Regimes:

$$R^h > R^l$$

2. Transition probabilities:

$$F_{hh} \equiv p(R_{t+1} = R^h \mid R_t = R^h)$$
$$F_{ll} \equiv p(R_{t+1} = R^l \mid R_t = R^l)$$

3. Mean durations:

$$1/F_{hl} \quad 1/F_{lh}$$

Equilibrium conditions

$$\lambda_t = u_T(t)$$

$$p_t^N = \left(\frac{1-\omega}{\omega}\right)\left(\frac{c_t^T}{c_t^N}\right)^{\eta+1}$$

$$\lambda_t = \frac{\beta}{q_t}\mathbb{E}_t\left[\lambda_{t+1}\right] + \mu_t$$

$$q_t b_{t+1} \geq -\kappa(y_t^T + p_t^N y_t^N) \quad \text{with equality if } \mu_t > 0$$

$$c_t^N \;=\; y_t^N$$

$$c_t^T = y_t^T - q_t b_{t+1} + b_t$$

Effects of news & liquidity regimes

- News effects:
  1. Good news at t strengthen incentives to borrow
  2. …and increase expected future borrowing capacity
  3. …but if y^T_{t+1} turns out to be low, prob. of crisis rises (higher leverage)
- Global liquidity shifts:
  1. Persistent high liquidity induces more borrowing
  2. Expectation of regime switch is low
  3. Shift to low liquidity after spell of high liquidity triggers severe crisis (low prob. by construction)
- DE and SP have identical information sets

Constrained-efficient financial regulator (planner's) problem:

$$V(b,z) = \max_{p^N, c^T, c^N, b'} \left[u\left(\left[\omega \left(c^T\right)^{-\eta} + (1-\omega)\left(c^N\right)^{-\eta} \right]^{-\frac{1}{\eta}} \right) + \beta \mathbb{E} V(b', z') \right]$$

$$z = (y^T, s, q)$$

subject to:

$$c^T + qb' = b + y^T$$

$$c^N = y^N$$

$$qb' \geq -\kappa(y^T + p^N y^N)$$

$$p^N = \left(\frac{1-\omega}{\omega}\right)\left(\frac{c^T}{c^N}\right)^{\eta+1}$$

Externality & optimal policy

- Wedge in the marginal costs of borrowing in periods of financial stability ($\mu_t = 0$) :

1. DE: $$u_T(t) = \frac{\beta}{q_t}\mathbb{E}_t\left[u_T(t+1)\right]$$

2. SP: $$u_T(t) = \frac{\beta}{q_t}\mathbb{E}_t\left[u_T(t+1) + \mu_{t+1}\psi_{t+1}\right]$$

$$\psi_t \equiv \kappa\left[\frac{1-\omega}{\omega}(1+\eta)\frac{c^T}{y^N}\right]$$

- SP's allocations can be implemented by introducing a "debt tax" $[q_t/(1+\tau_t)]b_{t+1}$ set to: $$\tau_t = \frac{\mathbb{E}_t\left[\mu_{t+1}\psi_{t+1}\right]}{\mathbb{E}_t\left[u_T(t+1)\right]}$$

Is there room for ex-post intervention?

- No because planner cannot alter allocations when the constraint binds (assuming uniqueness)

- The allocations need to satisfy resource constraint, credit constraint, and pricing condition:

$$c_t^T = (1+\kappa) y_t^T + \kappa \frac{1-\omega}{\omega} \left(\frac{c_t^T}{y_t^N} \right)^{1+\eta} y_t^N + b_t$$

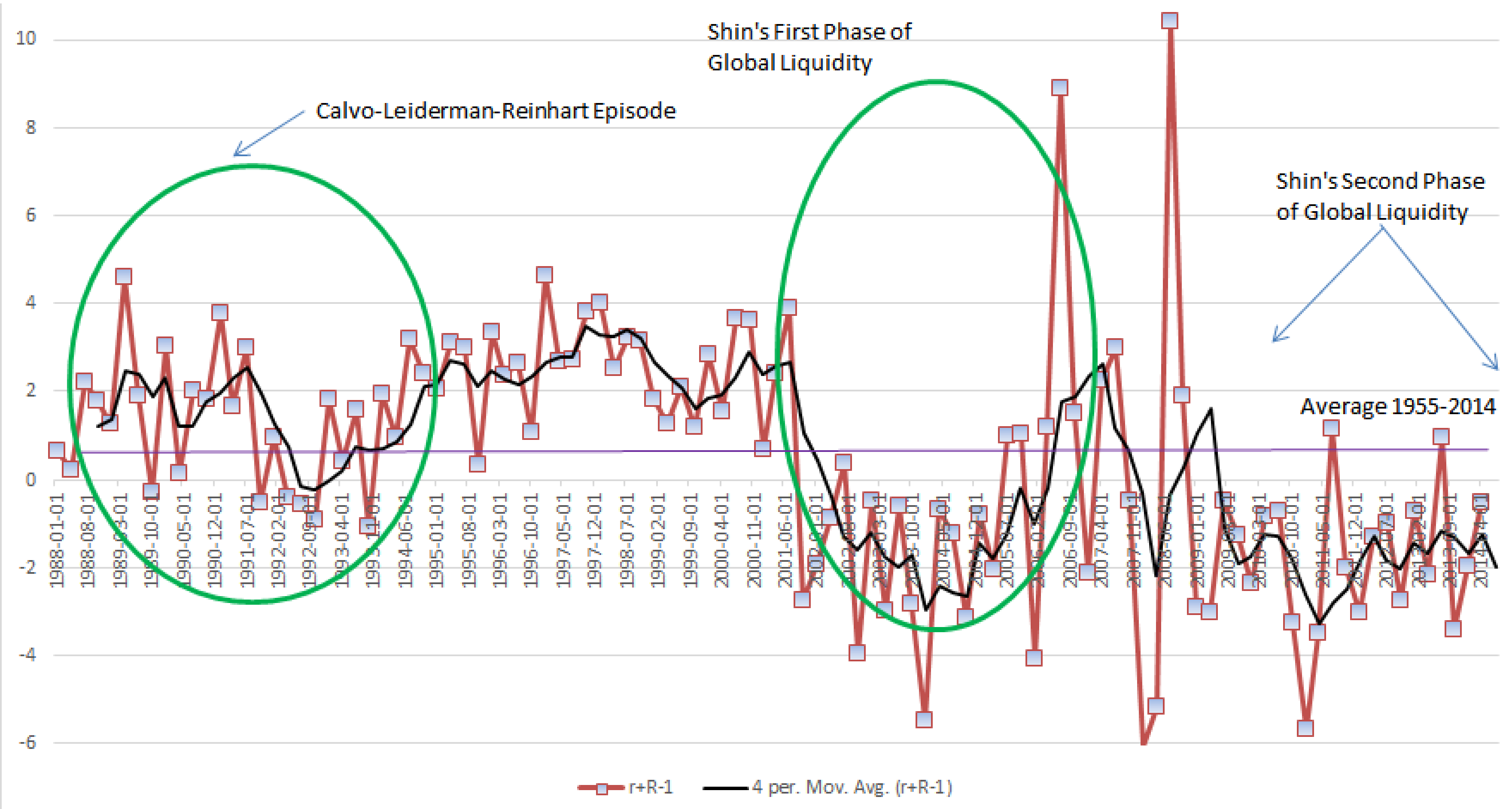
- Same for DE and SP, so for same income and initial NFA, both attain the same consumption & welfare when the constraint binds

- Any tax such that the constraint binds in DE with tax when it binds for SP is optimal (usually 0)

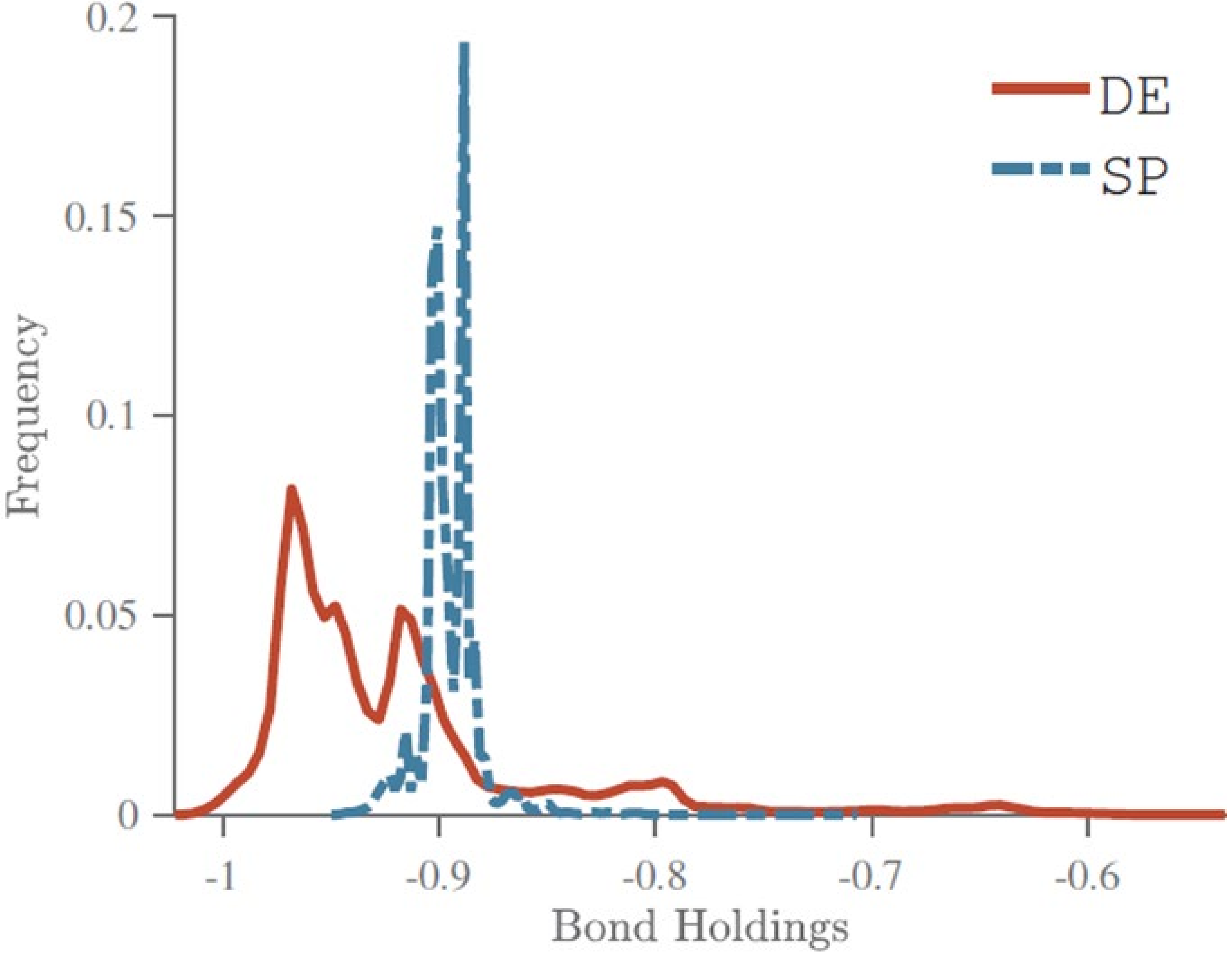
Baseline calibration

Parameter	Value	Parameter	Value
y^N	1	N_{y^T}	3
$E[y^T]$	1	ρ_{y^T}	0.54
σ_{y^T}	0.059	β	0.91
γ	2	η	0.205
κ_L	0.32	ω	0.32
θ	$\frac{2}{3}$	R^h	1.0145
R^l	0.9672	F_{hh}	0.9333
F_{ll}	0.6		

Global liquidity phases
(ex post real return on 90-day U.S. Tbills)



Baseline results: Long-run dist. of NFA



Baseline results: Key moments

Long-run Moments	(1) DE	(2) SP
$E[B/Y]$ %	-29.62	-28.89
$\sigma(CA/Y)$ %	3.18	1.75
Welfare Gain [1] %	n/a	0.12
Prob of Crisis [2] %	3.51	0.01

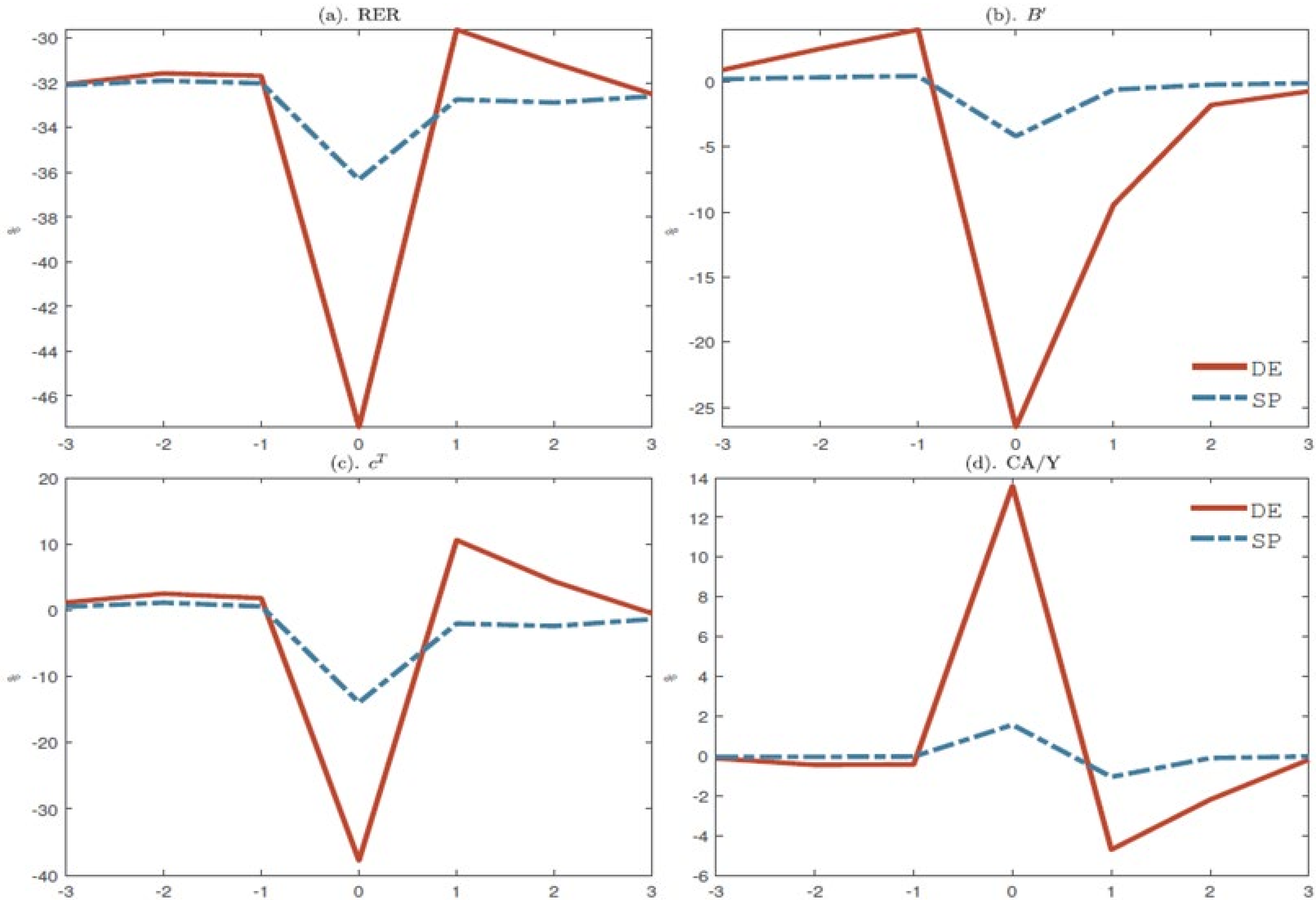
Effective policy

	Financial Crisis Moments	
$\Delta C\%$	-14.39	-4.68
$\Delta RER\%$	-45.55	-12.65
$\Delta CA/Y\%$	13.47	1.57
Ω^{C} [3]	4.63	1.49
Ω^{RER}	5.61	1.54
$\Omega^{CA/Y}$ %	13.37	1.70
$E[\tau]$ pre-crisis [4] %	n/a	9.22

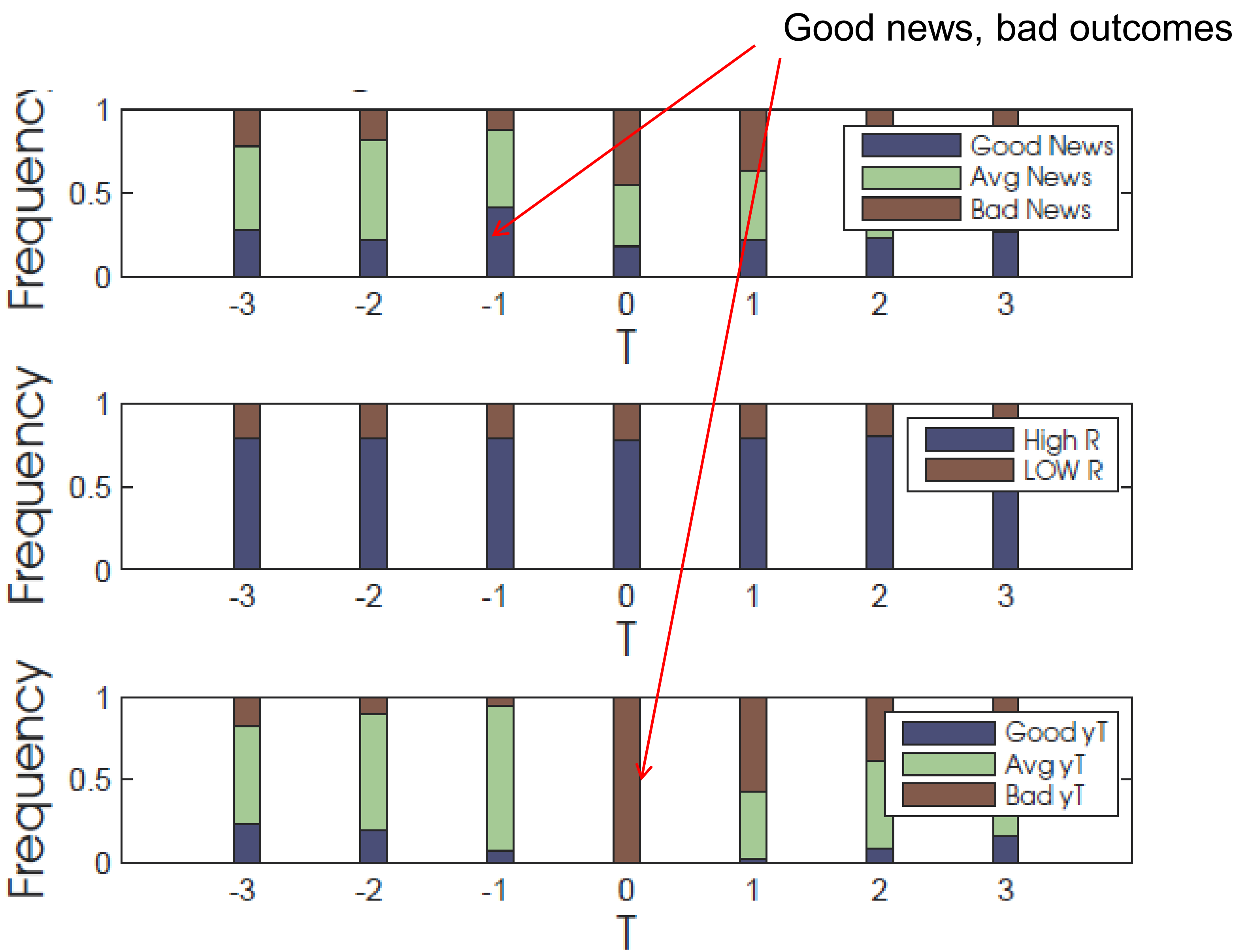
Large crises

Large amplification

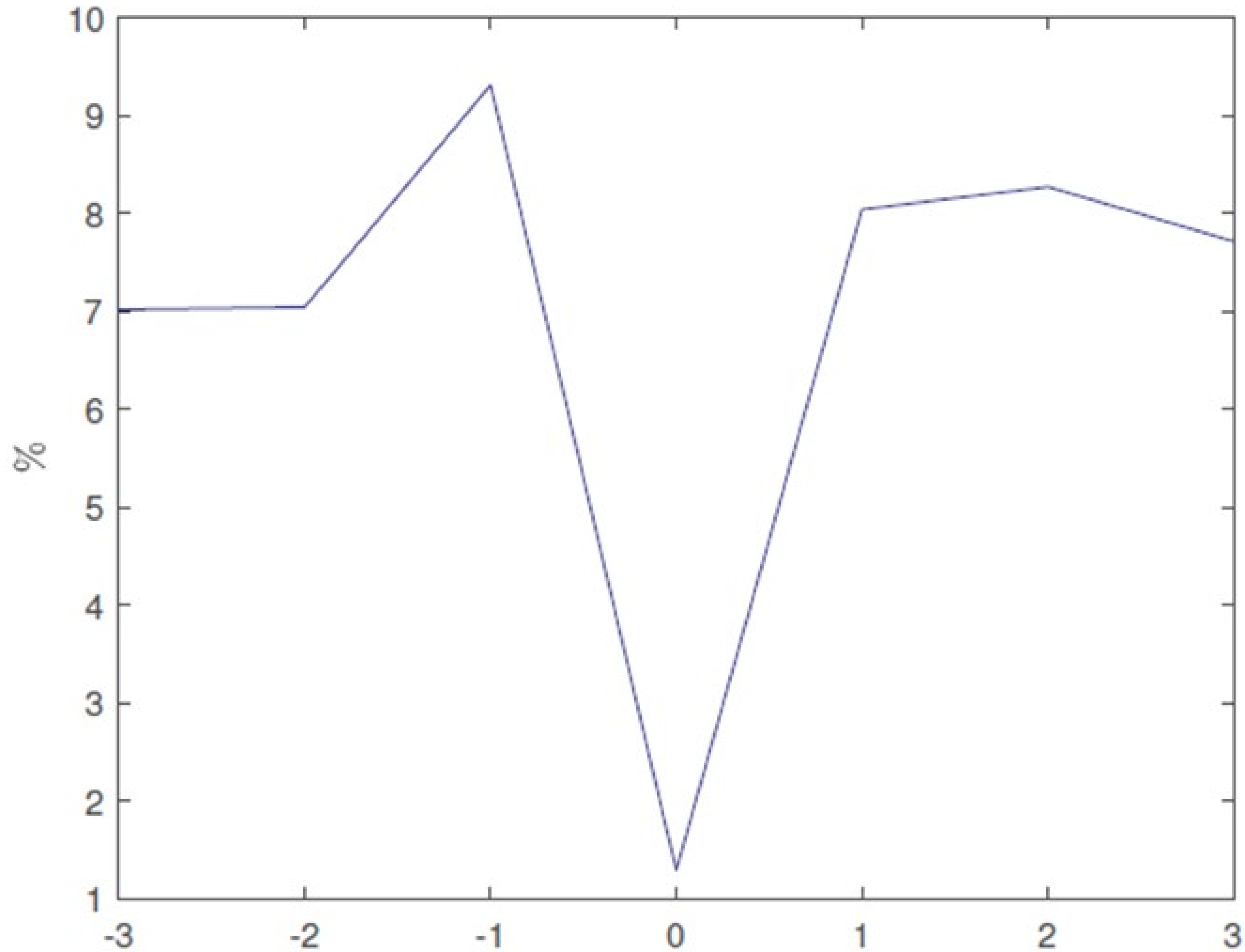
Financial crises with and without MPP



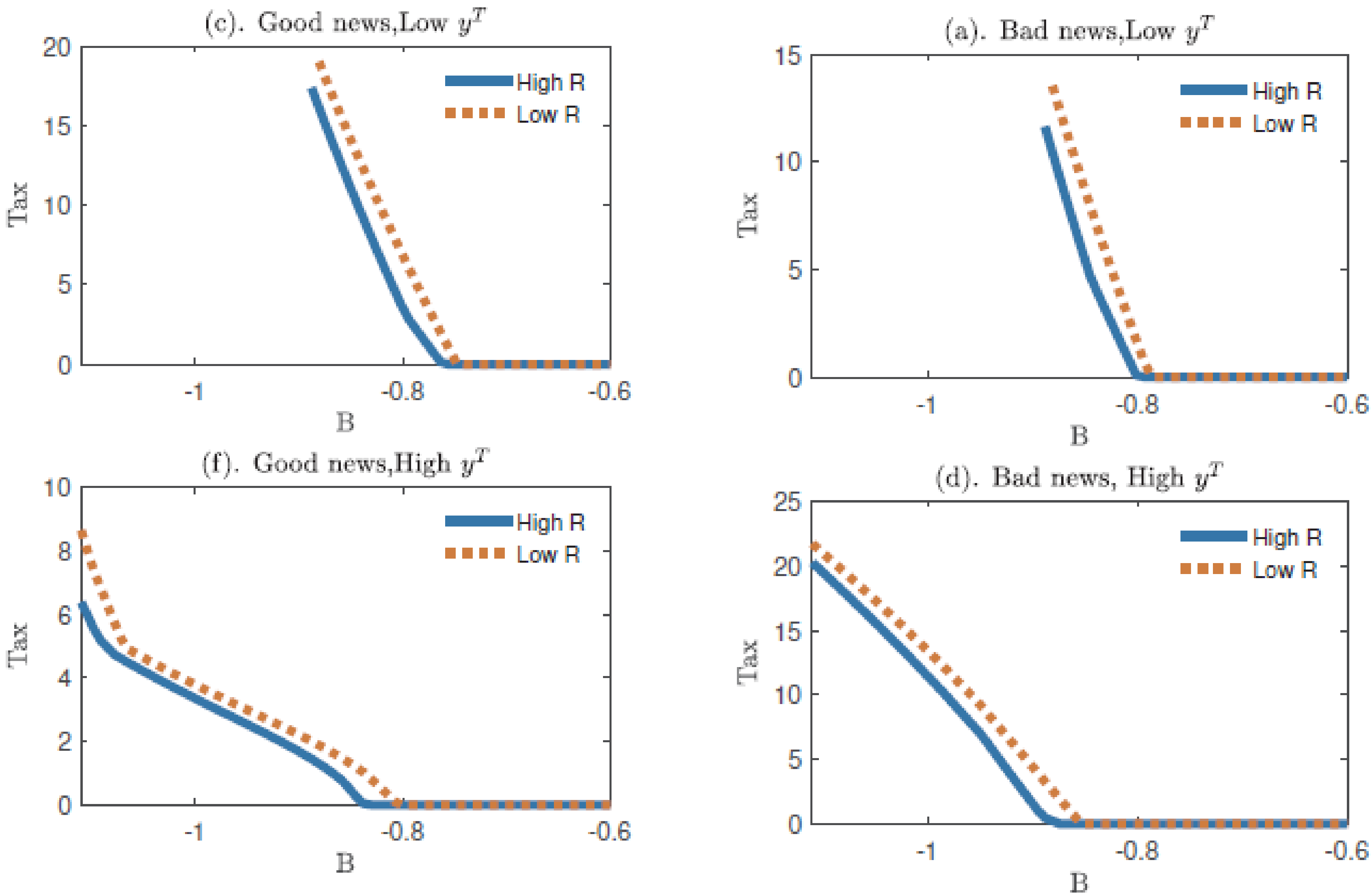
Shocks during crisis events



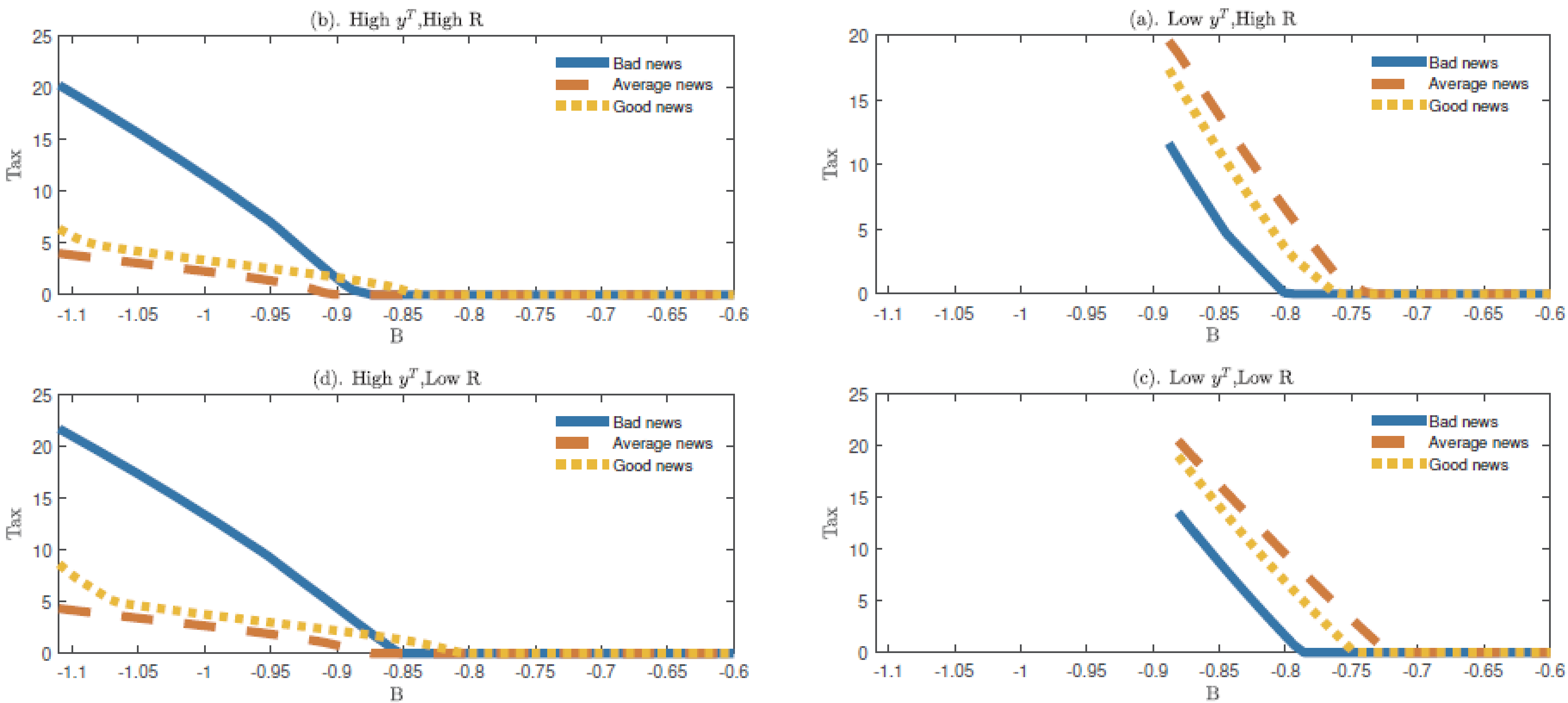
Optimal MP debt tax around crises



Optimal tax schedule & global liquidity



Optimal tax & news shocks



Production and ex-post interventions
(Hernandez & Mendoza (2017))

- Sectoral production with tradable intermediate goods and TFP shocks:

$$y_T = z_t^T (m_t^T)^{\alpha_T} \qquad y_N = z_t^N (m_t^N)^{\alpha_N}$$

- Firms maximize profits facing world input prices:

$$\alpha_T z_t^T m_t^{T^{\alpha_T - 1}} = p^m \qquad p_t^N \alpha_N z_t^N m_t^{N^{\alpha_N - 1}} = p^m$$

- In equilibrium, resource and collateral constraints are:

$$c^T + A^T + p^m(m^T + m^N) + qb' = b + z^T m^{T^{\alpha_T}}$$
$$c^N + A^N = z^N m^{N^{\alpha_N}}$$
$$qb' \geq -\kappa[(1-\alpha T) z^T m^{T^{\alpha T}} + (1-\alpha N) p^N z^N m^{N^{\alpha N}}]$$

- Deflation of nontradables price affects sectoral production and factor allocations during crises

Constrained efficient planner's problem

$$V(b,e) = \max_{p^N, c^T, c^N, m^T, m^N, b'} \left[u\left(\left[\omega (c_t^T)^{-\eta} + (1-\omega)(c_t^N)^{-\eta} \right]^{-\frac{1}{\eta}} \right) + \beta \mathbb{E} V(b', e') \right]$$

s.t.

$$c^T + A^T + p^m(m^T + m^N) + qb' = b + z^T m^{T^{\alpha_T}}$$

$$c^N + A^N = z^N m^{N^{\alpha_N}}$$

$$qb' \geq -\kappa[(1-\alpha T) z^T m^{T^{\alpha T}} + (1-\alpha N) p^N z^N m^{N^{\alpha N}}]$$

$$p^N = \left(\frac{1-\omega}{\omega}\right)\left(\frac{c^T}{c^N}\right)^{\eta+1}$$

where $e \equiv (z^T, s, q)$.

Optimal financial policy

- Same pecuniary externality as endowment economy justifies ex-ante (macro-prudential) policy
- In addition, when μ*>0 planner wants to prop up p^N, hence social marginal cost of inputs differs from p^m:
  1. Lower than p^m in T sector:

$$\alpha_T z_t^T {m_t^T}^{\alpha_T - 1} = p^m \left[\frac{\lambda_t^*}{\lambda_t^* + \mu_t^* \kappa (1 - \alpha_T)} \right]$$

  2. Higher than p^m in N sector :

$$p_t^N \alpha_N z_t^N {m_t^N}^{\alpha_N - 1} = p^m \left[\frac{\lambda_t^*}{\lambda_t^* + \mu_t^* \kappa (1 - \alpha_N) \left[1 - \left(\frac{p_t^N c_t^N + c_t^T}{c_t^T} \right) \left(1 + \frac{A^T}{c_t^N} \right) \right]} \right]$$

- It is optimal to tax (subsidize) inputs in N (T) sector

$$p^m (1 + \tau_t^N) \qquad\qquad p^m (1 - s_t^T)$$

Calibration to Colombia

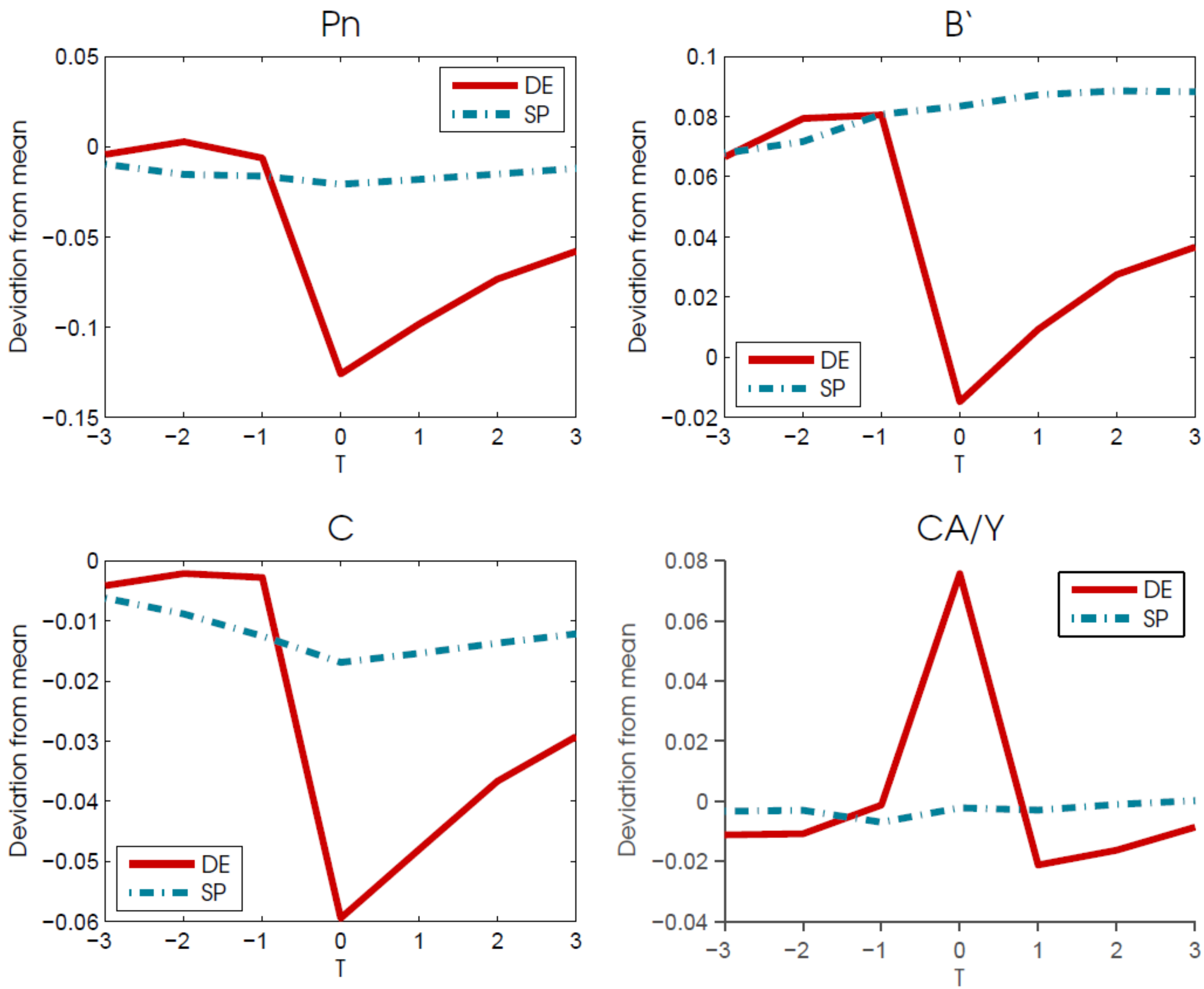
Parameter		Value	Target
Risk Aversion	γ	2.000	Standard value
Elasticity of Subs.	η	0.205	Bianchi et al. (16)
Consumption Aggregator	ω	0.415	Share of tradable output
News Precision	θ	2/3	Bianchi et al. (16)
T Input % in T Sector	α_T	0.420	Avg. % of T input/T Gross out.
T Input % in NT Sector	α_N	0.158	Avg. % of T input/NT Gross out.
Autocorr. T prod.	ρ_z^T	0.845	Output Autocorrelation
SD T prod.	σ_z^T	0.016	Output Volatility
Low Liq. Real Int. Rate	R^h	1.013	Bianchi et al. (16)
High Liq. Real Int. Rate	R^l	0.992	Bianchi et al. (16)
Low Liq. Cont. Prob.	F_{hh}	0.983	Bianchi et al. (16)
High Liq. Cont. Prob.	F_{ll}	0.900	Bianchi et al. (16)
Discount Factor	β	0.989	Avg. Colombian NFA/GDP
% Assets Pledgeable	κ	0.850	Crisis probability

Long-run & crises moments

Long-run Moments	(1) DE	(2) SP
$\mathbb{E}[B/Y]$	77.35%	74.95%
$\sigma(CA/Y)$	0.023	0.009
Welfare Gain	n.a.	1.38 %
Prob. Of Crisis	2.80%	0.00%
Pr$(\mu_t > 0)$	15.57%	4.95%
Prob. of MPtax region	n.a.	11.78%

Effectiveness of Optimal Policies		
ΔC	-6.03 %	-1.57%
ΔRER	-7.99%	-1.08%
$\Delta CA/Y$	7.70%	-0.31%
$\mathbb{E}[\tau]$ pre-crisis	n.a.	0.1%
$\mathbb{E}[s^T]$ pre-crisis	n.a.	0.1%
$\mathbb{E}[\tau^N]$ pre-crisis	n.a.	0.8%

Crises event analysis



Application to LTV model (credibility)

Fisherian model with assets as collateral

Bianchi-Mendoza (2018 JPE)

1. RBC-SOE model with Fisherian constraint
2. Rep. firm-household uses assets in fixed supply as collateral for debt and working capital
3. Working capital needed to pay for inputs and subject to collateral constraint (credit-induced output drops)
4. Shocks: TFP (z_t), world interest rate (R_t), and regime-switching LTV or global liquidity (κ_t).
5. Calibrated to U.S. and OECD data

Rep. firm-household problem

$$\max \; \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t - G(h_t))$$

$$u(c - G(h)) = \frac{\left(c - \chi \frac{h^{1+\omega}}{1+\omega}\right)^{1-\sigma} - 1}{1-\sigma} \quad \omega > 0, \sigma > 1$$

s.t.

$$q_t k_{t+1} + c_t + \frac{b_{t+1}}{R_t} = q_t k_t + b_t + [z_t F(k_t, h_t, v_t) - p_v v_t] \quad (\lambda_t)$$

$$-\frac{b_{t+1}}{R_t} + \theta p_v v_t \leq \kappa_t q_t k_t \quad (\mu_t)$$

DE optimality conditions

$$z_t F_h(k_t, h_t, v_t) = G'(h_t)$$

$$z_t F_v(k_t, h_t, v_t) = p_v(1 + \theta\mu_t / u'(t))$$

$$u'(t) = \beta R_t \mathbb{E}_t \left[u'(t+1)\right] + \mu_t$$

$$q_t u'(t) = \beta \mathbb{E}_t \left[u'(t+1)\left(z_{t+1} F_k(k_{t+1}, h_{t+1}, v_{t+1}) + q_{t+1}\right) + \kappa_{t+1}\mu_{t+1} q_{t+1}\right]$$

Social planner's problem under discretion

$$\mathcal{V}(b,s) = \max_{c,b',q,h,v} u(c - G(h)) + \beta \mathbb{E}_{s'|s} \mathcal{V}(b',s')$$

s.t.

$$c + \frac{b'}{R} = b + zF(1,h,v) - p^v v$$

$$\frac{b'}{R} - \theta p^v v \geq -\kappa q$$

$$qu'(c - G(h)) = \beta \mathbb{E}_{s'|s} u'(\boxed{\mathcal{C}(b',s')} - G(\boxed{\mathcal{H}(b',s')}))(\boxed{\mathcal{Q}(b',s')} + z' F_k(1, \boxed{\mathcal{H}(b',s')}, \boxed{\boldsymbol{v}(b',s')}))$$
$$+ \kappa \boxed{\boldsymbol{\mu}(b',s')} \boxed{\mathcal{Q}(b',s')}$$

$$zF_h(1,h,v) = G'(h)$$

$$zF_v(1,h,v) = p^v \left(1 + \frac{\theta\mu}{u'(c - G(h))}\right)$$

$$\mu \geq 0$$

$$\mu \left(\frac{b'}{R} - \theta p^v v + \kappa q\right) = 0$$

(Relaxed) Planner's problem <u>under discretion</u>

$$\mathcal{V}(b,s) = \max_{c,b',q,\mu,h,v} u(c - G(h)) + \beta \mathbb{E}_{s'|s} \mathcal{V}(b',s')$$

s.t.

$$c + \frac{b'}{R} = b + zF(1,h,v) - p^v v \qquad (\lambda)$$

$$\frac{b'}{R} - \theta p^v v \geq -\kappa q \qquad (\mu^*)$$

$$qu'(c - G(h)) =$$

$$\beta \mathbb{E}_{s'|s} u'(\mathcal{C}(b',s') - G(\mathcal{H}(b',s')))(\mathcal{Q}(b',s') + z' F_k(1, \mathcal{H}(b',s'), v(b',s')))$$

$$+ \kappa' \boldsymbol{\mu}(b',s') \mathcal{Q}(b',s') \qquad (\xi)$$

Recursive SP equilibrium without commitment

Definition. *The recursive constrained-efficient equilibrium is defined by the policy function* $b'(b,s)$ *with associated decision rules* $c(b,s)$, $h(b,s)$, $v(b,s)$, $\mu(b,s)$, *pricing function* $q(b,s)$ *and value function* $\mathcal{V}(b,s)$, *and the conjectured function characterizing the decision rule of future planners* $\mathcal{B}(b,s)$ *and the associated decision rules* $\mathcal{C}(b,s)$, $\mathcal{H}(b,s)$, $\mathbf{v}(b,s)$, $\boldsymbol{\mu}(b,s)$ *and asset prices* $\mathcal{Q}(b,s)$, *such that these conditions hold:*

1. *Planner's optimization:* $\mathcal{V}(b,s)$ *and the functions* $\{b'(b,s), c(b,s), h(b,s), v(b,s), q(b,s)\}$ *solve the Bellman equation defined in Problem (12) given* $\{\mathcal{B}(b,s), \mathcal{C}(b,s), \mathcal{H}(b,s), \mathbf{v}(b,s), \boldsymbol{\mu}(b,s), \mathcal{Q}(b,s)\}$, *and* $\mu(b,s)$ *satisfies condition (5).*

2. *Time consistency (Markov stationarity): The conjectured policy rules that represent optimal choices of future planners match the corresponding recursive functions that represent optimal plans of the current regulator:* $b'(b,s) = \mathcal{B}(b,s)$, $c(b,s) = \mathcal{C}(b,s)$, $h(b,s) = \mathcal{H}(b,s)$, $v(b,s) = \mathbf{v}(b,s)$, $\mu(b,s) = \boldsymbol{\mu}(b,s)$, $q(b,s) = \mathcal{Q}(b,s)$.

SP's optimality conditions

- Without commitment:

$$c_t :: \qquad \lambda_t = u'(t) \boxed{- \xi_t u''(t) q_t}$$

LHS of K-EuEq>0

$$b_{t+1} :: \qquad u'(t) = \beta R_t \mathbb{E}_t \left\{ u'(t+1) - \xi_{t+1} u''(t+1) \mathcal{Q}_{t+1} + \xi_t \Omega_{t+1} \right\} + \xi_t u''(t) q_t + \mu_t^*$$

$$q_t :: \qquad \xi_t = \frac{\kappa_t \mu_t^*}{u'(t)}$$

- With commitment (needs full SP, not relaxed):

$$c_t :: \qquad \lambda_t = u'(t) \boxed{- \xi_t u''(t) q_t} + \boxed{\xi_{t-1} u''(t) (q_t + z_t F_k(t) + \kappa_t \mu_t q_t)}$$

LHS of K-EuEq >0

RHS of K-EuEq at t-1<0

$$b_{t+1} :: \qquad \lambda_t = \beta R_t \mathbb{E}_t \lambda_{t+1} + \mu_t^* + \boxed{\mu_t \nu_t}$$

WK effects>0

$$q_t :: \qquad \xi_t = \xi_{t-1}(1 + \kappa_t \mu_t) + \frac{\kappa_t (\boxed{\mu_t \nu_t} + \mu_t^*)}{u'(t)}$$

Commitment & time consistency

- If μ_t >0, the planner views the effects of the choice of b_{t+1} on C_{t+1}, and hence on q_t, differently depending on its ability to commit

- ***Commitment**:* Promise lower C_{t+1} ,to prop up q_t, because $q_t(C_t, C_{t+1})$ is decreasing in C_{t+1}, but at t+1 this is suboptimal=> time inconsistency

- ***Discretion**:* The planner of date t considers how its choices affect choices of the planner of t+1 => Markov stationarity sustains time-consistent plans

- ***Conditionally const-efficient SP**:* takes as given $q^{DE}(b', s)$ and is time-consistent by construction, but still internalizes pec. externality (see Bianchi & Mendoza (2010))

Optimal, time-consistent policy

1. Macroprudential component (tackles standard pecuniary externality when μ_t=0 but $E_t[\mu_{t+1}] > 0$):

$$\tau_t^{MP} = \frac{E_t\left[-\kappa_{t+1}\mu_{t+1}^{*}\frac{u_{cc}(t+1)}{u_c(t+1)}Q_{t+1}\right]}{E_t\left[u_c(t+1)\right]}$$

2. Ex-post component (tackles effects on future planners & props up value of collateral when $\mu_t > 0$)

$$\tau_t^{FP} = \frac{E_t\left[\frac{\kappa_t\mu_t^{*}}{u_c(t)}\Omega_{t+1}\right]}{E_t\left[u_c(t+1)\right]} + \frac{\kappa_t\mu_t^{*}\frac{u_{cc}(t)}{u_c(t)}q_t}{\beta R_t E_t\left[u_c(t+1)\right]}$$

Other things one can prove

1. Primal SP's problem is equivalent to a planner's problem choosing optimal debt tax
2. Tax on debt is non-negative
3. Collateral constraint can be derived from enforcement problem
4. Firm-household problem is equivalent to DE with households and firms making separate decisions
5. Extension to investment with adjustment costs
6. Comparison and problems with the analysis in Jeanne and Korinek

Calibration to OECD & U.S. data

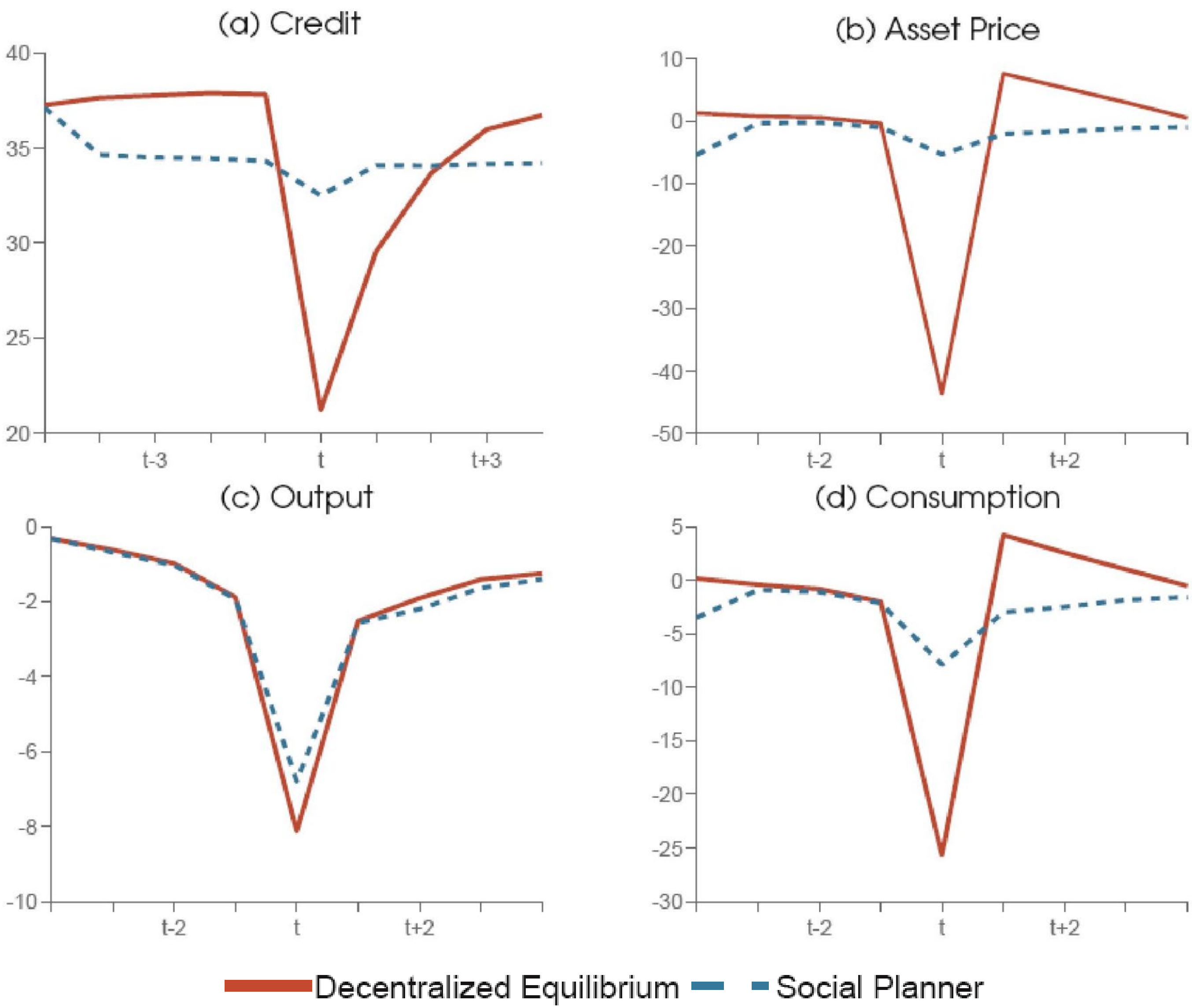
Parameters set independently	Value	Source/Target
Risk aversion	$\sigma = 1.$	Standard value
Share of inputs in gross output	$\alpha_v = 0.45$	Cross country average OECD
Share of labor in gross output	$\alpha_h = 0.352$	OECD GDP Labor share = 0.64
Labor disutility coefficient	$\chi = 0.352$	Normalization (mean $h = 1$)
Frisch elasticity	$1/\omega = 2$	Keane and Rogerson (2012)
Working capital coefficient	$\theta = 0.16$	U.S. WK/GDP ratio=0.133
Tight credit regime	$\kappa^L = 0.75$	U.S. post-crisis LTV ratios
Normal credit regime	$\kappa^H = 0.90$	U.S. pre-crisis LTV ratios
Interest rate	$\bar{R} = 1.1\%, \rho_R = 0.68$	U.S. 90-day T-Bills
	$\sigma_R = 1.86\%$	

Parameters set by simulation	Value	Target
TFP shock	$\rho_z = 0.78, \sigma_z = 0.01$	GDP sd. & autoc. (OECD average)
Share of assets in gross output	$\alpha_k = 0.008$	Value of collateral matches total credit
Discount factor	$\beta = 0.95$	Private $NFA = -25$ percent
Transition prob. κ^H to κ^L	$P_{H,L} = 0.1$	4 crises every 100 years (Appendix E2)
Transition prob. κ^L to κ^L	$P_{L,L} = 0.$	1 year duration of crises (Appendix E2)

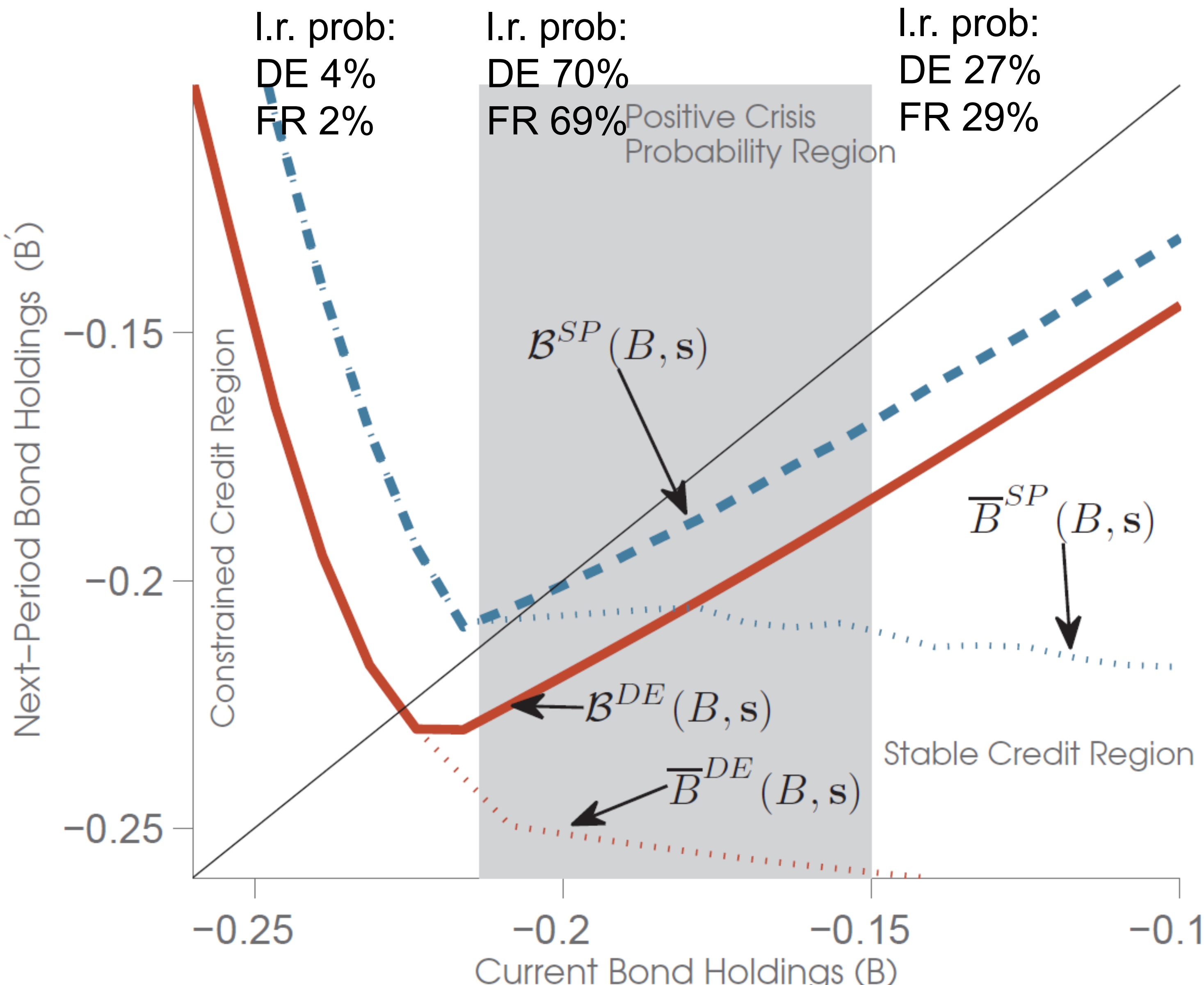
Main findings

1. Optimal policy reduces freq. & magnitude of crises:
   - Prob. of crisis falls from 4% to 0.02%
   - Asset prices fall 39 ppts less (44% v. 5%).
   - Credit and consumption fall about 10 ppts less
   - Welfare is 0.3% higher
2. Mean excess return, Sharpe ratio, and market price of risk rise much less
3. Endogenous fat tails in the distribution of returns
4. Optimal tax on debt is 3.6% on average, 0.7 corr. with leverage, and half as volatiles as GDP
5. Simpler policies (fixed taxes and “financial Taylor rule) are much less effective and can be welfare reducing
6. Higher (lower) prices with (without) commitment than in DE

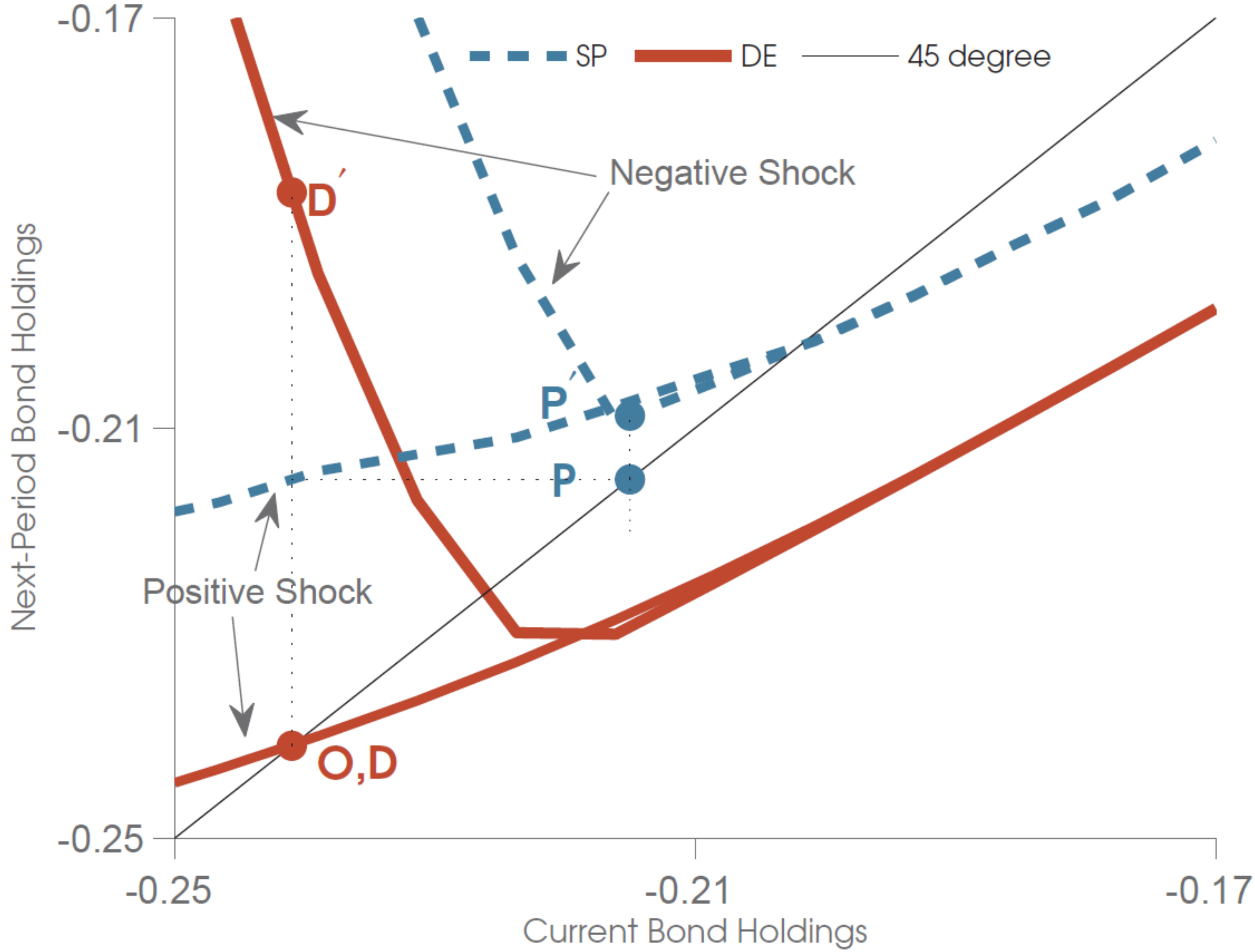
Financial crises & policy effectiveness



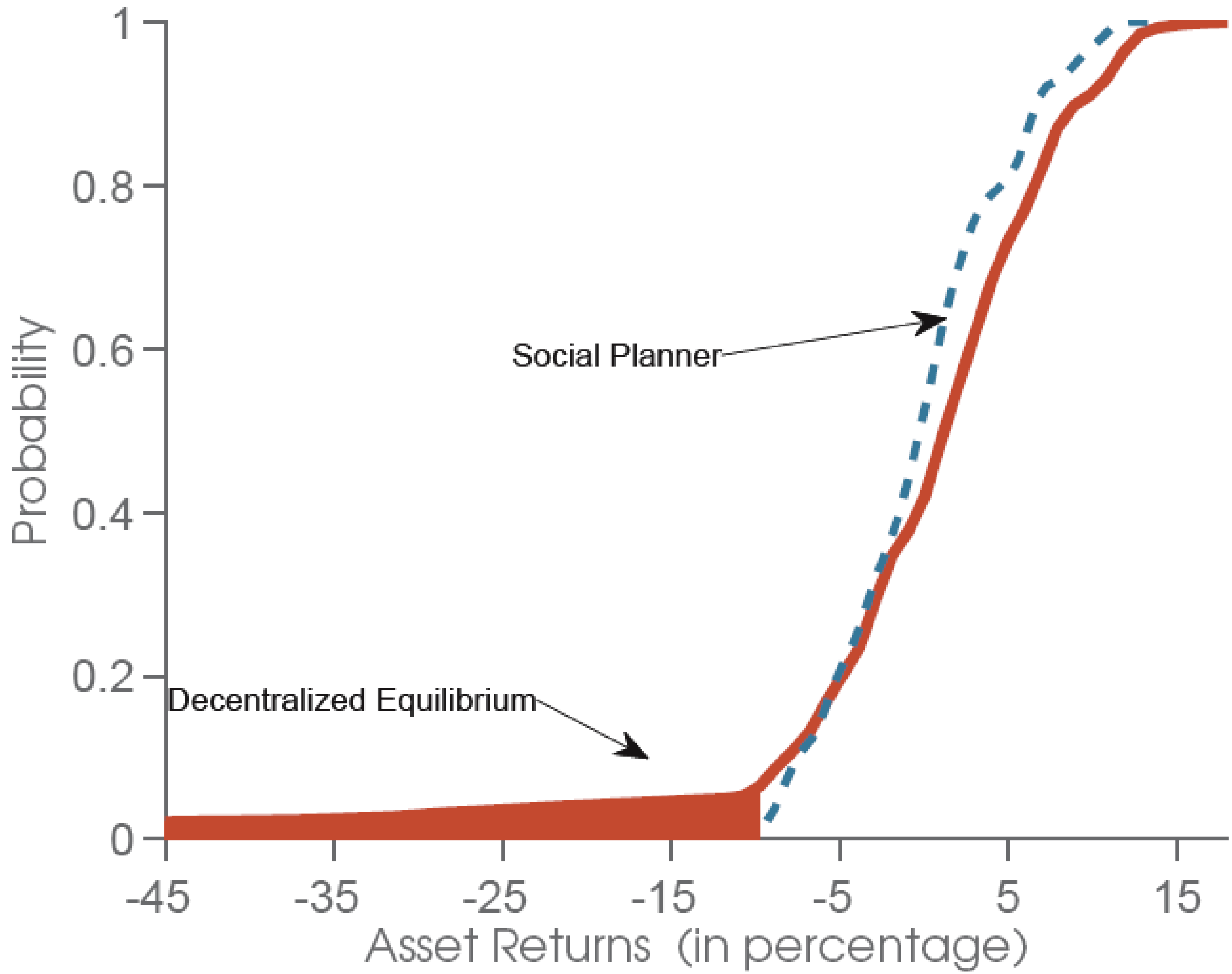
Nonlinear bond choices (low TFP state)



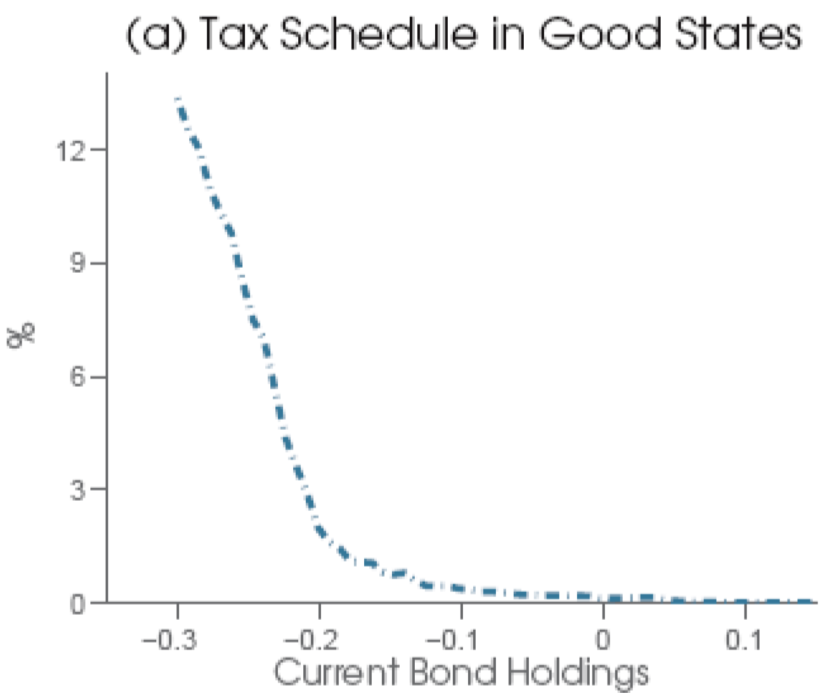
Fisherian amplification dynamics

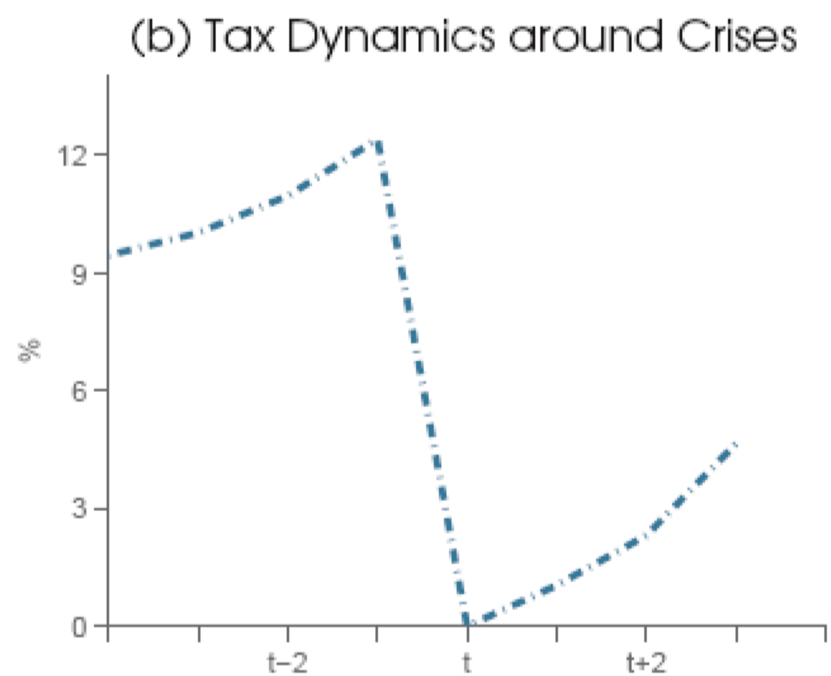


Endogenous “fat tails” in asset returns



Complexity of the optimal policy





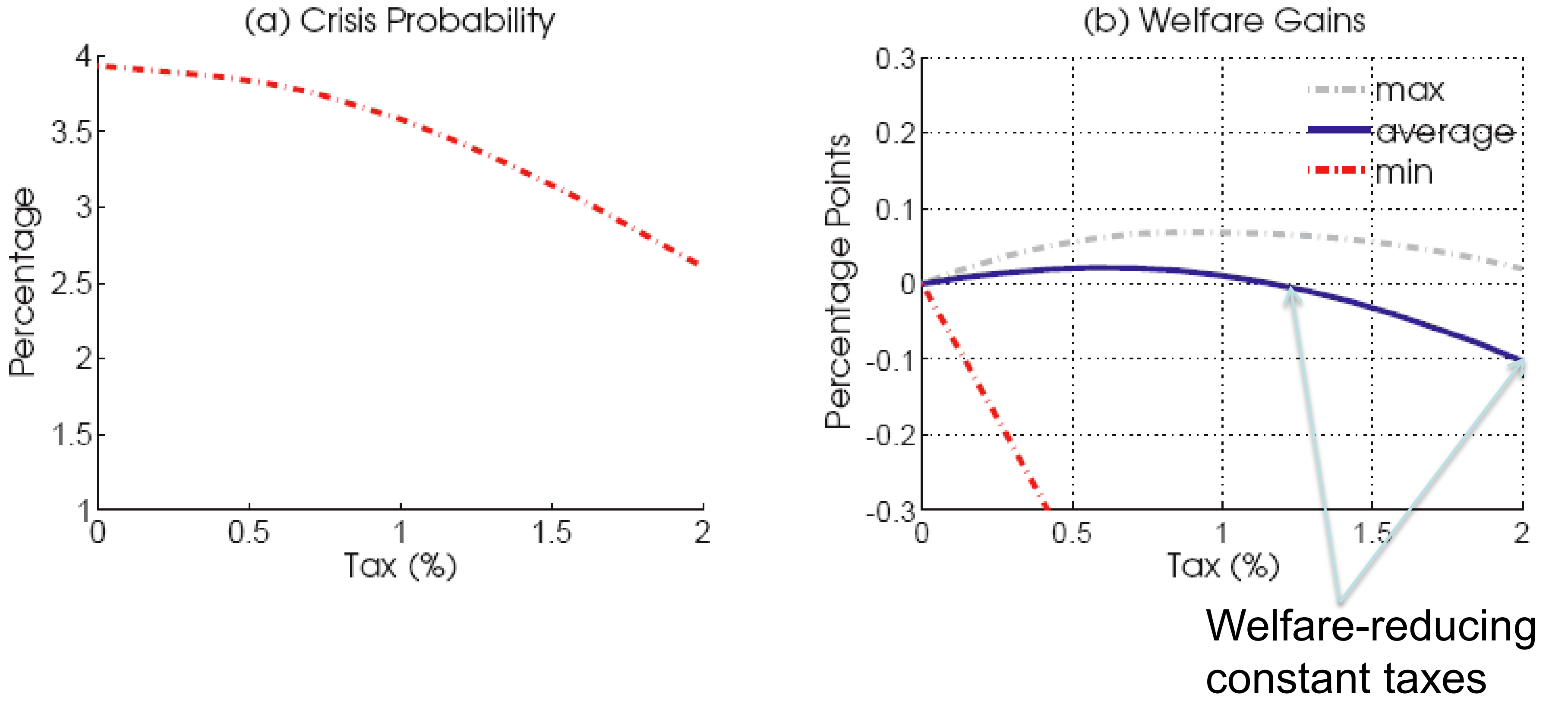
Comparison with simple policies

$\tau = 0.6, \eta_b = 2, \bar{b} = -0.23$

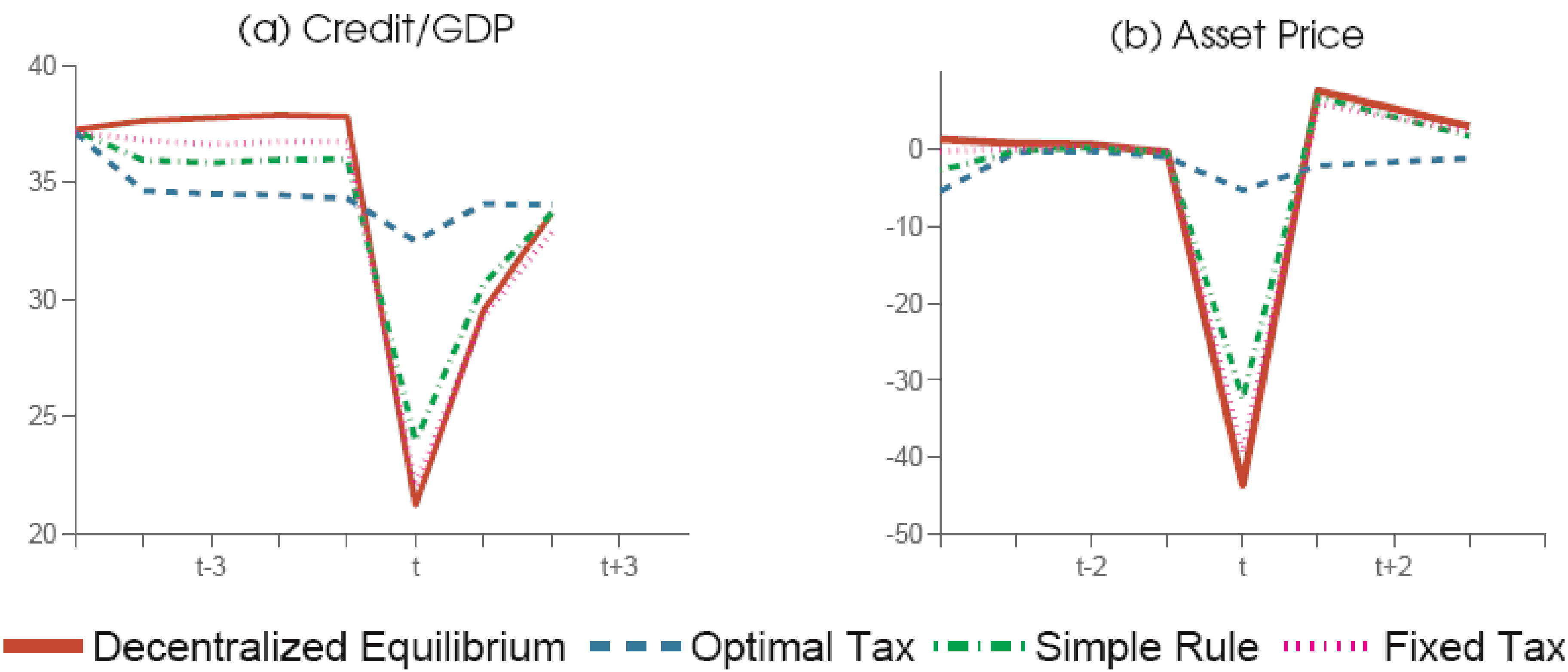
	Decentralized Equilibrium	Optimal Policy	Best Taylor	Best Fixed
Welfare Gains (%)	–	0.30	0.09	0.03
Crisis Probability (%)	4.0	0.02	2.2	3.6
Drop in Asset Prices (%)	-43.7	-5.4	-36.3	-41.3
Equity Premium (%)	4.8	0.77	3.9	4.3
Tax Statistics				
Mean	–	3.6	1.0	0.6
Std relative to GDP	–	0.5	0.2	–
Correlation with Leverage	–	0.7	0.3	–

Financial Taylor Rule: $\tau = \max[0, \tau_0(b_{t+1}/\bar{b})^{\eta_b} - 1]$

Effects of constant taxes on crisis prob. & welfare



Effects of simple policies on magnitude of crises



Credibility in DTI models: Liability dollarization

(Mendoza-Rojas (2018))

- Standard DTI model:

Max.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \quad u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}.$$

$$c_t = \left[\omega \left(c_t^T\right)^{-\eta} + (1-\omega)\left(c_t^N\right)^{-\eta}\right]^{-\frac{1}{\eta}}$$

s.t.

$$q_t^* b_{t+1} + c_t^T + p_t^N c_t^N = b_t + y_t^T + p_t^N y_t^N$$

$$q_t^* b_{t+1} \geq -\kappa(y_t^T + p_t^N y_t^N)$$

Debt issued in T units at world price q*=1/R* **(intermediation is inessential)**

Add banks with liability dollarization

- Risk-neutral banks borrow abroad at price q_t^* in T units to fund domestic loans at price q_t^c in units of domestic consumption (p_t^c is CPI in T units, which is also the real exchange rate, RER)

- No-arbitrage condition (akin to Fisher eq.):

$$q_t^c = \frac{q_t^* \mathbb{E}_t \left[p_{t+1}^c\right]}{p_t^c}$$

- Ex-ante (in ***c***) and ex-post (in ***c^T***) real interest rates:

$$R_{t+1}^c \equiv 1/q_t^c = \frac{R_{t+1}^* p_t^c}{\mathbb{E}_t\left[p_{t+1}^c\right]} \qquad \tilde{R}_{t+1}^T \equiv \frac{R_{t+1}^c p_{t+1}^c}{p_t^c}$$

- Nearly frictionless intermediation

Domestic agents

Max. $$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \quad u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}.$$

$$c_t = \left[\omega \left(c_t^T\right)^{-\eta} + (1-\omega)\left(c_t^N\right)^{-\eta}\right]^{-\frac{1}{\eta}}$$

s.t.

resources generated by new debt

$$\boxed{q_t^c p_t^c b_{t+1}^c} + c_t^T + p_t^N c_t^N = \boxed{p_t^c b_t^c} + y_t^T + p_t^N y_t^N$$

outstanding debt repayment

$$q_t^c p_t^c b_{t+1}^c \geq -\kappa(y_t^T + p_t^N y_t^N)$$

Domestic CPI (real ex. rate):

$$p_t^c = \left[\omega^{\frac{1}{1+\eta}} + (1-\omega)^{\frac{1}{1+\eta}} \left(p_t^N\right)^{\frac{\eta}{1+\eta}}\right]^{\frac{1+\eta}{\eta}}$$

LD effects on domestic borrowers

1. Ex-post RER alters burden of debt repayment

$$p_t^c b_t^c$$ (*smaller burden if RER depreciates, or ex-post RIR falls*)

2. Ex-ante RER alters price of new domestic debt

$$q_t^* \mathbb{E}_t \left[p_{t+1}^c \right]$$ (*higher if RER is expected to appreciate, or ex-ante RIR falls*)

3. Risk-taking incentive: lower expected borrowing cost

$$u_T(t) = \beta R_{t+1}^* \mathbb{E}_t \left[u_T(t+1) \right] + \underbrace{\boxed{\beta \mathrm{Cov}_t(u_T(t+1), \tilde{R}_{t+1}^T)}}^{(-)} + \mu_t$$

- All three present even without credit constraint

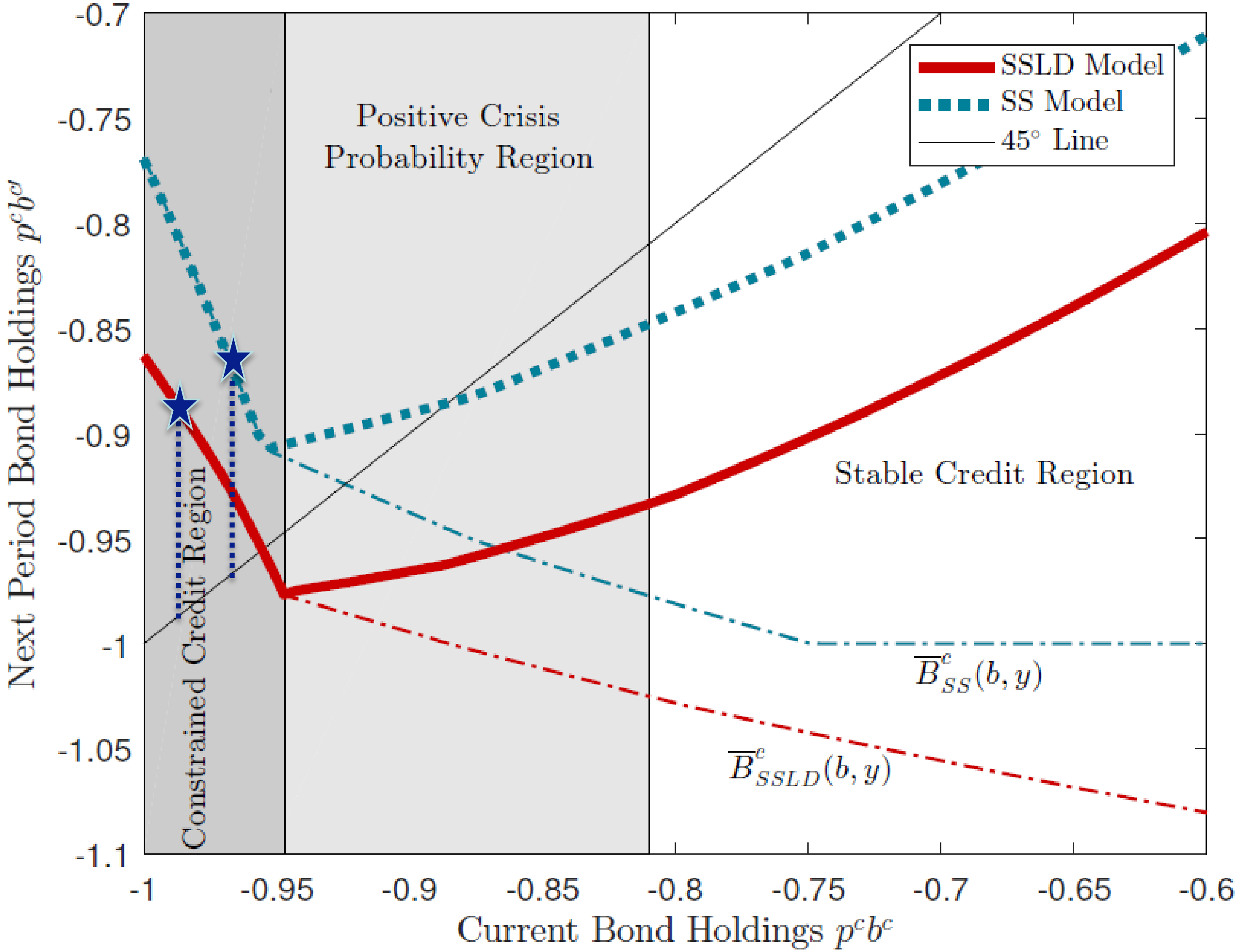
Calibration (Bianchi, 2011)

Parameter	Value
γ	2
η	0.205
ω	0.31
β	0.91
q^*	0.96
ρ_{y^T}	0.54
σ_{y^T}	0.059
y^N	1.00
κ	0.32

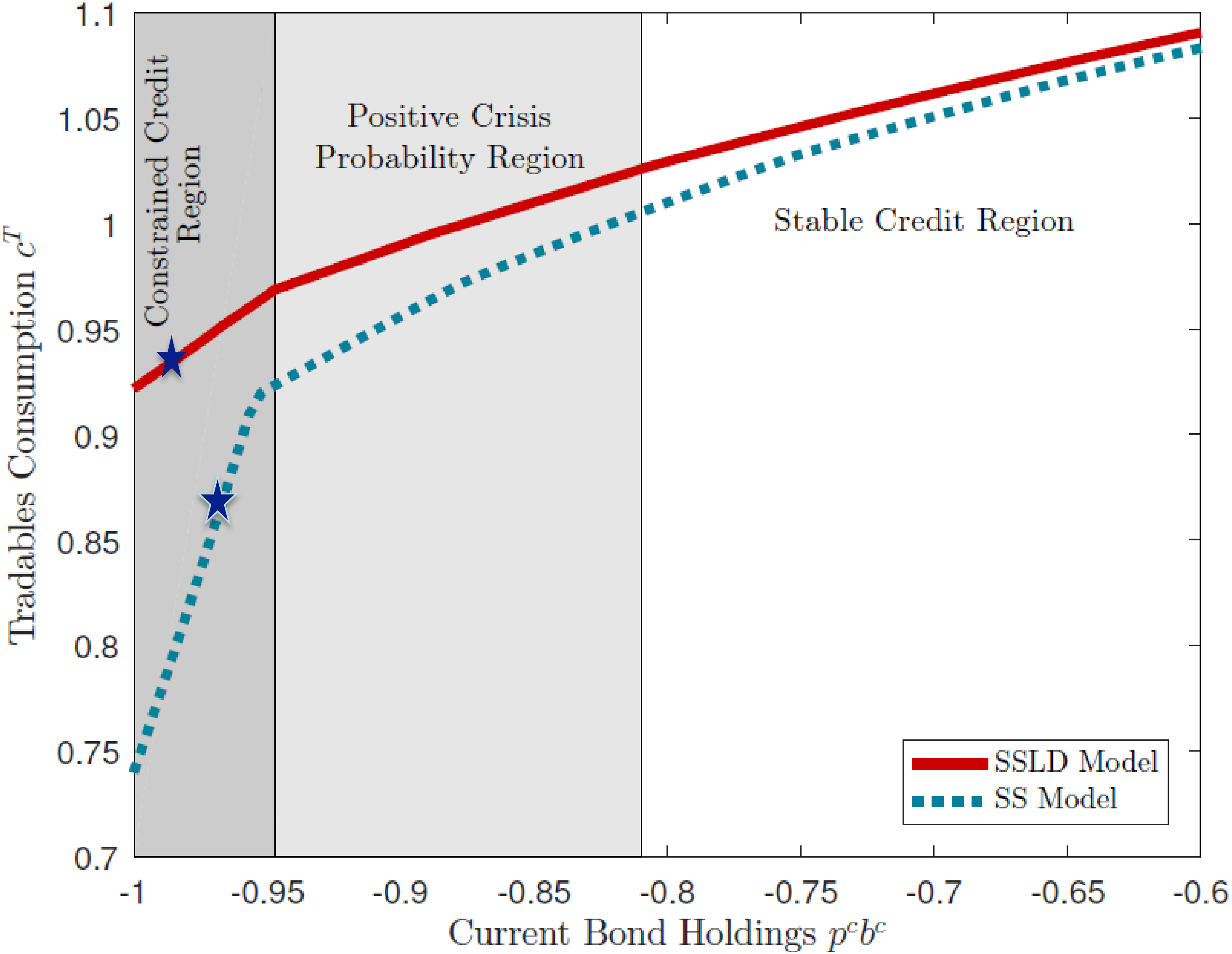
SS-SSLD comparison

1. Risk-taking incentive equivalent on average to 46 bpts. cut in R* (4% to 3.54%)
2. SSLD economy sustains higher debt (29.4% v. 27.2% of GDP on average)
3. Sudden Stops are less frequent (3.8% v. 4.8%), milder, and reached with higher income, but also more in line with empirical regularities
4. Milder crises largely due to fall in **ex-ante RER** or RIR-C (also higher income & lower ex-post RER)
5. Welfare is 0.26% higher (LD is desirable because of endogenous state contigency)

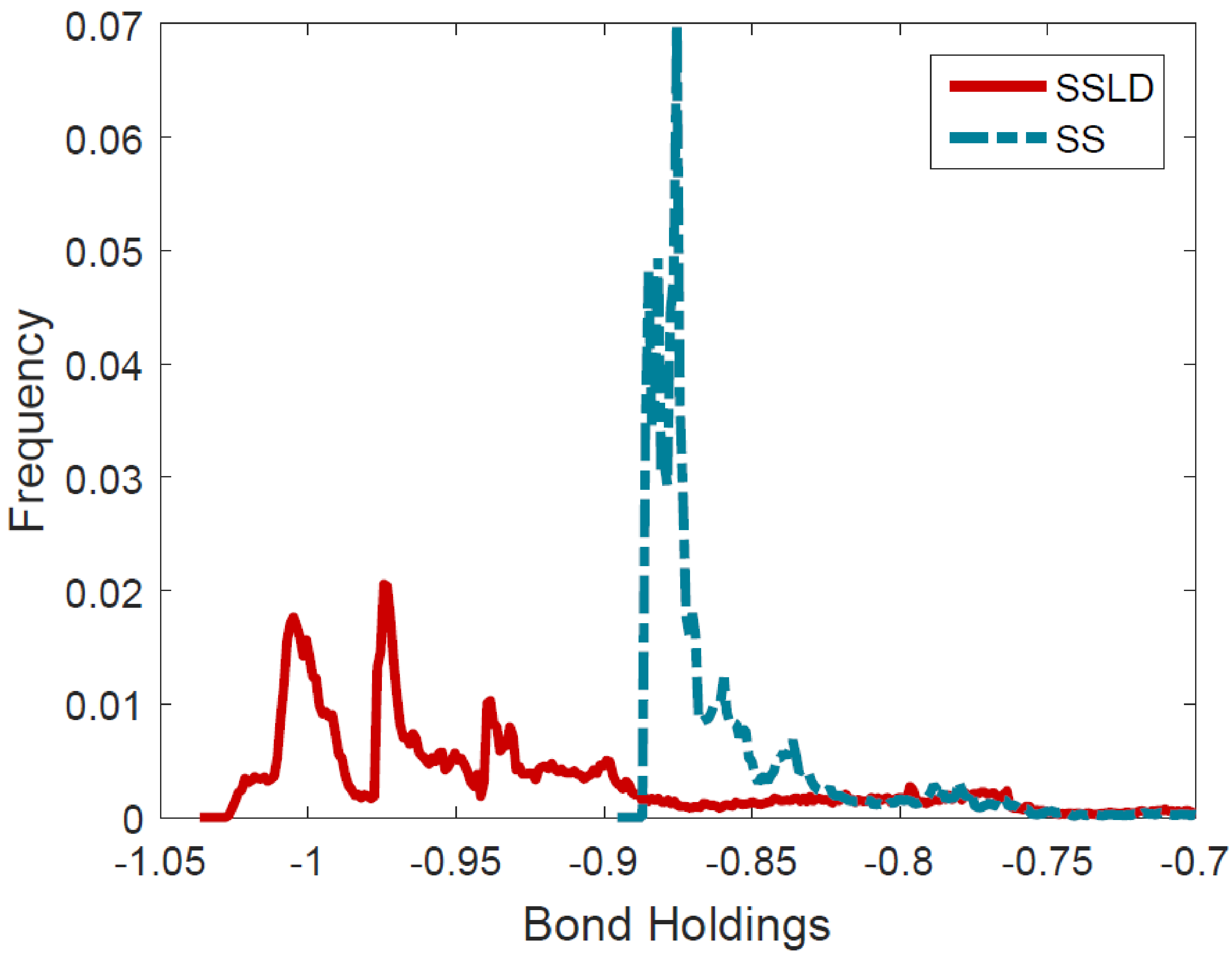
Debt decision rules: SS v. SSLD



Tradables consumption dec. rules: SS v. SSLD



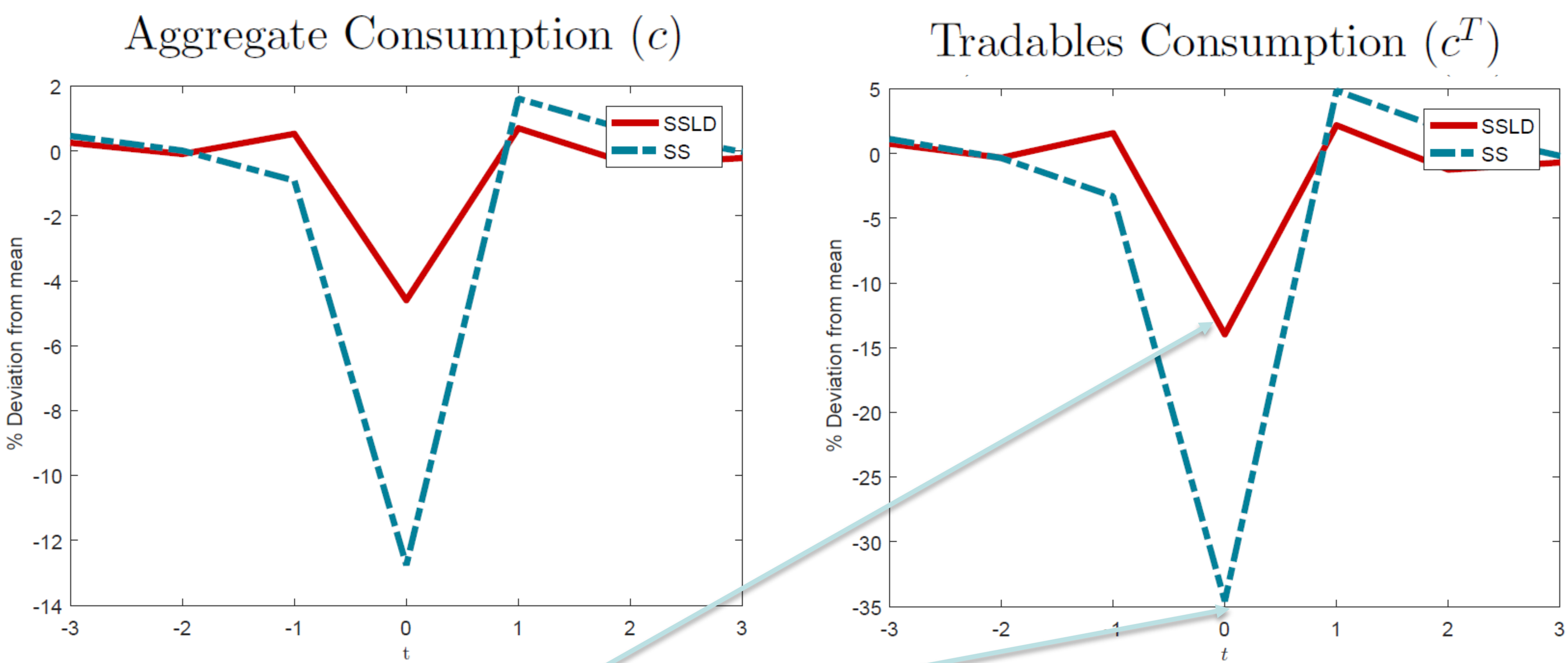
Long-run bond distributions: SS v. SSLD



Comparing SS and SSLD models

	SS	SSLD
Average $(p^c b^c/Y)\%$	-27.16	-29.41
Average TB/Y Ratio	1.22	1.12
Welfare gain[1]%	n/a	0.26
Prob. of Sudden Stops[2]%	4.76	3.83
Prob$(\mu_t > 0)$ %	9.30	35.38
Prob of MP tax region %	n/a	n/a
Median Debt Tax Rate τ %	n/a	n/a
Median Capital Control Rate θ %	n/a	n/a
Average c	0.989	0.989
Average fall in c in Sudden Stops[3]	- 12.73	-4.60

Sudden Stops in consumption: SS v. SSLD

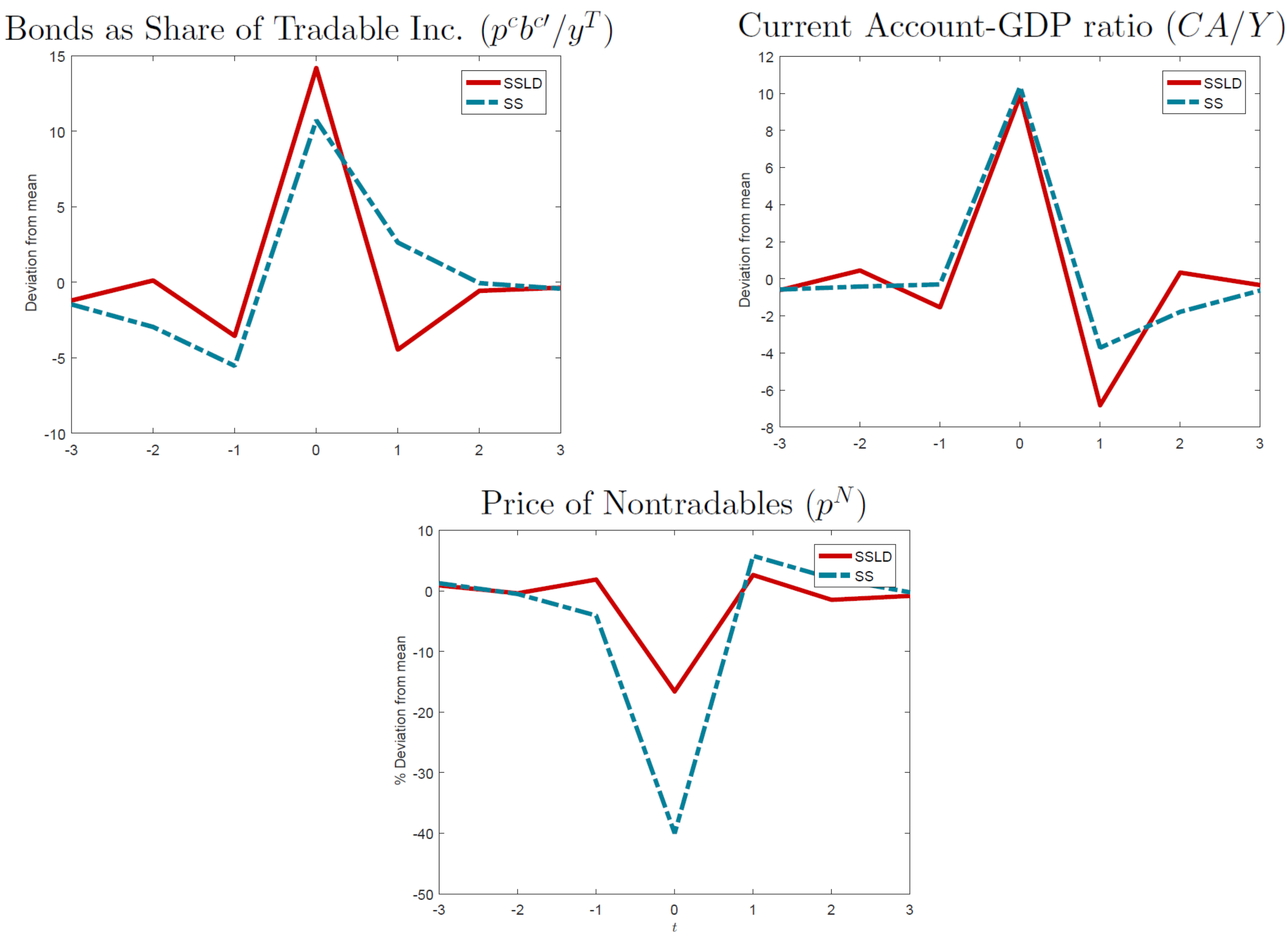


$$\Delta c^T = \Delta y^T_t + \Delta p^c_t b^c_t + \Delta q^c_t p^c_t b^c_{t+1} \quad = 0.2$$

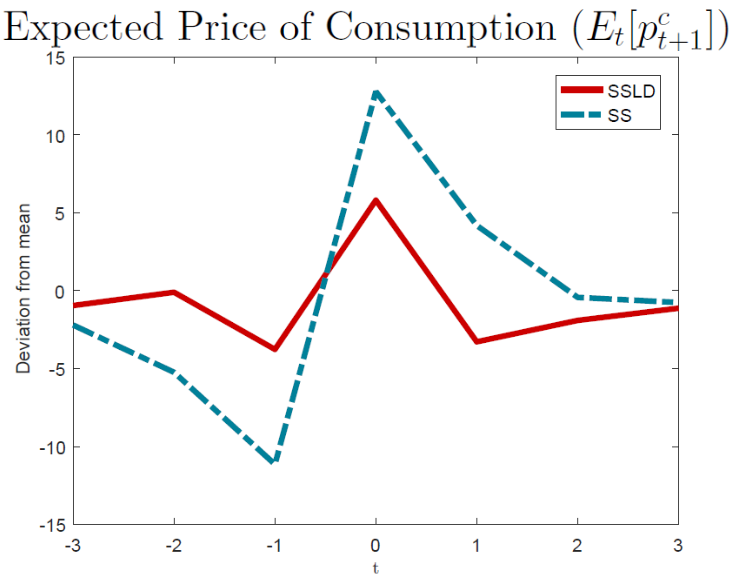
$$0.021 \quad 0.034 \quad \boxed{0.149}$$

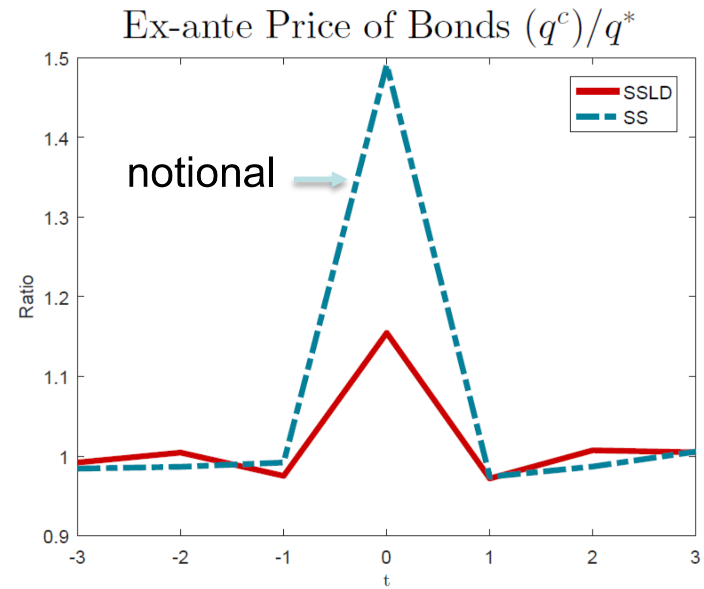
3/4ths of consumption gain are due to ex-ante RIR /RER effect!

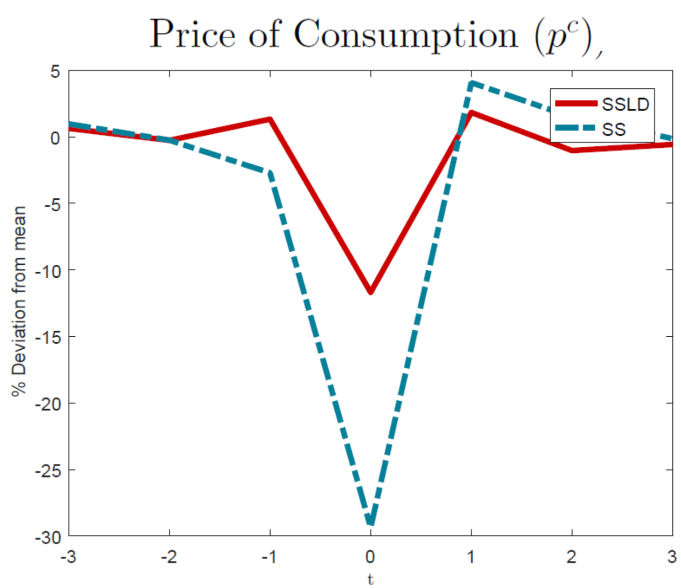
Sudden Stops in debt, CA & NTs price: SS v. SSLD

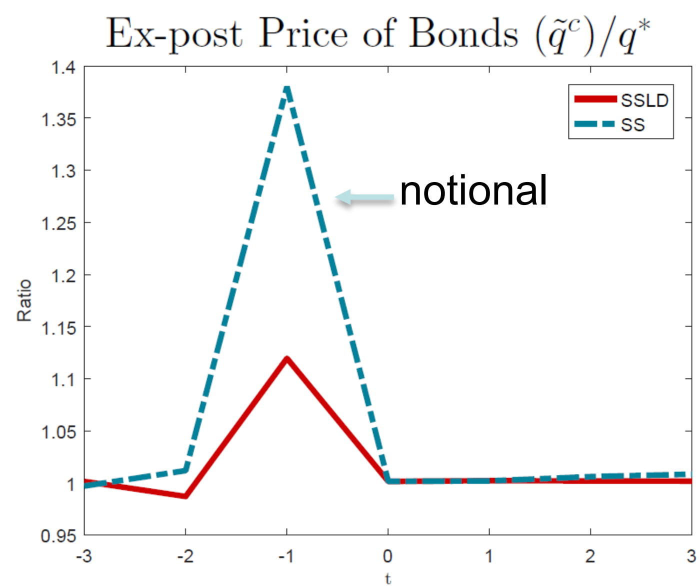


Sudden Stops in prices: SS v. SSLD









Planner's problem under commitment

$$\max_{\{c_t^T, b_{t+1}^c\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t(c_t^T, y_t^N))$$

s.t.

$$q_t^* \mathbb{E}_t \left[p^c(c_{t+1}^T, y_{t+1}^N) \right] b_{t+1}^c + c_t^T = p^c(c_t^T, y_t^N) b_t^c + y_t^T$$

$$q_t^* \mathbb{E}_t \left[p^c(c_{t+1}^T, y_{t+1}^N) \right] b_{t+1}^c \geq -\kappa (y_t^T + p^N(c_t^T, y_t^N) y_t^N)$$

- Euler eq. for μ_t=0 (<u>externalities</u>): standard MP ext. (+)

$$u_T(t) = \beta \mathbb{E}_t \left[\left[u_T(t+1) + \boxed{\mu_{t+1} \kappa \overline{y}^N p^{N\prime}(t+1)} \right] \tilde{R}_{t+1}^T \boxed{\Psi(t+1)} \right]$$

intermediation ext. > or < 1

$$\Psi(t+1) \equiv \left(\frac{1-\psi(t)}{1-\psi(t+1)} \right)$$

ex-post RER ex-ante RER risk-taking incentive

$$\psi(t) \equiv p^{c\prime}(t) b_t^c \left[1 - \left(\frac{\mathbb{E}_{t-1}[\lambda_t]}{\lambda_t} + \frac{\mathrm{Cov}_{t-1}(\lambda_t, p^c(t))}{\lambda_t \mathbb{E}_{t-1}[p^c(t)]} \right) \right]$$

Instruments to implement optimal policy

- Capital controls: tax θ_t on intermediaries inflows:

$$q_t^c = \frac{q_t^*}{\boxed{(1+\theta_t)}} \frac{\mathbb{E}_t\left[p_{t+1}^c\right]}{p_t^c}$$

- Domestic regulation: tax τ_t on domestic debt:

$$q_t^c p_t^c b_{t+1}^c + c_t^T + p_t^N c_t^N = p_t^c b_t^c \boxed{(1+\tau_t)} + y_t^T + p_t^N y_t^N + \boxed{T_t}$$

- Euler equation with policy intervention:

$$u_T(t) = \boxed{(1+\tau_t)(1+\theta_t)} \beta \mathbb{E}_t\left[u_T(t+1)\tilde{R}_{t+1}^T\right] + \mu_t^{DE}$$

  - Equivalent effects on marginal cost of borrowing

- But capital controls move debt away from constraint:

$$q^* \mathbb{E}_t(p_{t+1}^c) b_{t+1}^c \geq -\kappa \boxed{(1+\theta)} (y_t^T + p_t^N y_t^N)$$

Time inconsistency & optimal taxes

- At *t*, induce higher expected c_{t+1} to boost $q^c{}_t$, but at *t+1* higher RER increases debt repayment burden

$$\lambda_t = \frac{u_T(t) + \mu_t \kappa p^{N\prime}(t) y_t^N - p^{c\prime}(t) b_t^c \frac{q_{t-1}^*}{\beta} \boxed{(\lambda_{t-1} - \mu_{t-1})}}{1 - p^{c\prime}(t) b_t^c}$$

- If μ_t=0, E[μ_{t+1}]>0, an *effective* debt tax implements planner' solution:

$$\tau_t^{ef} = \frac{\mathbb{E}_t \left[\left(u_T(t+1) + \mu_{t+1} \kappa \overline{y}^N p^{N\prime}(t+1) \right) \tilde{R}_{t+1}^T \Psi(t+1) \right]}{\mathbb{E}_t \left[\tilde{R}_{t+1}^T u_T(t+1) \right]} - 1$$

  - **No case for capital controls** (θ_t and τ_t are equivalent)

- When μ_t>0, planner's choices do not alter allocations

Conditionally efficient social planner

- Time-consistent SP that takes as given the bond pricing function of the unregulated DE

$$V(b^c, y^T, y^N) = \max_{\{b^{c\prime}, c^T\}} \left[u(c(c^T, y^N)) + \beta \mathbb{E}_{(y^{T\prime}, y^{N\prime})|(y^T, y^N)} \left[V(b^{c\prime}, y^{T\prime}, y^{N\prime}) \right] \right]$$

s.t.

$$q^{\mathrm{DE}}(b^c, y^T, y^N) p^c(c^T, y^N) b^{c\prime} + c^T = p^c(c^T, y^N) b^c + y^T$$

$$q^{\mathrm{DE}}(b^c, y^T, y^N) p^c(c^T, y^N) b^{c\prime} \geq -\kappa (y^T + p^N(c^T, y^N) y^N)$$

- Requires optimal debt tax and capital controls (the latter are needed to support the DE bond pricing function)

$$\tau_t = \frac{\mathbb{E}_t \left[\left(u_T(t+1) + \mu_{t+1} \kappa y^N_{t+1} p^{N\prime}(t+1) \right) \tilde{R}^c_{t+1} \tilde{\Psi}(t+1) \Omega(t+1) \right]}{\mathbb{E}_t \left[\tilde{R}^c_{t+1} u_T(t+1) \right]} \frac{q^{\mathrm{DE}}(t) p^c(t)}{q^*_t \mathbb{E}_t [p^c(t+1)]} - 1$$

$$\theta_t = \frac{q^*_t}{q^{\mathrm{DE}}(t)} \frac{\mathbb{E}_t [p^c(t+1)]}{p^c(t)} - 1$$

Simple policy rules

1. Constant taxes: $\tau_t = \tau \quad \theta_t = \theta$

2. Debt-tax Taylor Rule (credit targeting):

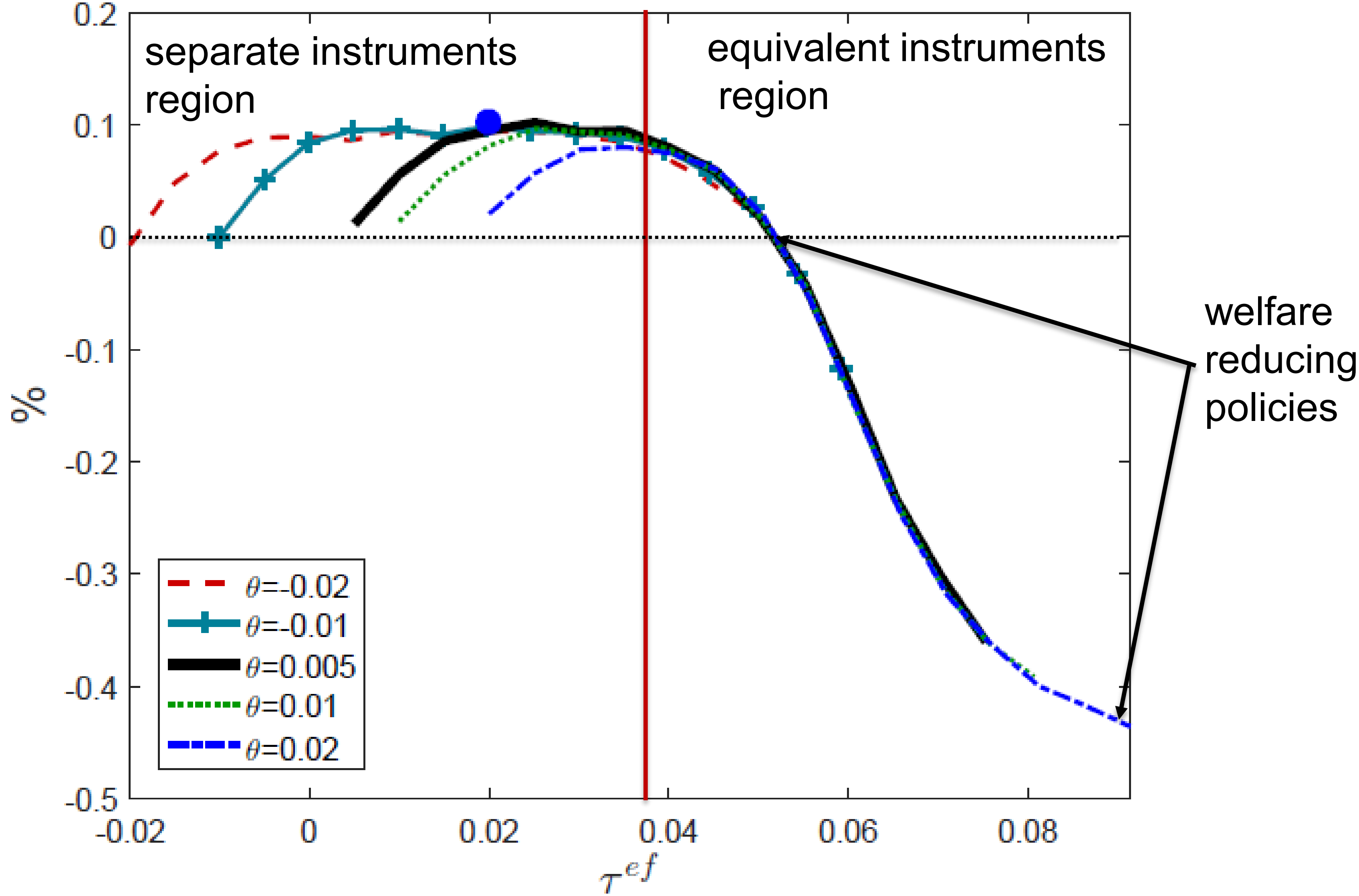
$$\tau_t = \max\left\{(1+\tau^*) \cdot \left(\frac{b_t^c}{\bar{b}^c}\right)^{\phi_T} - 1, 0\right\}$$

3. Capital-controls Taylor Rule (targeting RER level):

$$\theta_t = (1+\theta^*) \cdot \left(\frac{p_t^c}{\bar{p}^c}\right)^{\phi_C} - 1$$

- All three optimized to find largest welfare gain

Welfare with constant taxes



Effectiveness of simple rules v. CE-SP

$\phi_T = 2.75$

$\phi_C = -0.51$

Long-run Moments[1]	(1)	(2)	(3)	(4)	(5)
	DE	CT	TRT	TRCC	SP
Average $(P^c b^c / Y)$ %	-29.41	-29.07	-28.18	-30.49	-22.57
Welfare Gain[2]%	n/a	0.10	0.12	0.14	0.54
Prob. of Sudden Stops[3]%	3.83	3.23	2.76	3.55	0.00
Prob$(\mu_t > 0)$ %	35.38	31.84	7.15	71.08	22.87
Median Debt Tax Rate τ %	n/a	2.00	3.59	2.00	5.79
Median Capital Control Rate θ %	n/a	0.50	0.50	1.73	-12.78
Average c	0.989	0.989	0.990	0.989	1.024
Average change of c in Sudden Stops[4]%	-4.60	-4.87	-4.48	-2.06	n/a

Adding financial innovation and changes in beliefs

Adding financial innovation & beliefs

(Boz & Mendoza (2014))

- Allow for a time-varying LTV ratio:

$$\frac{b_{t+1}}{R} \geq -\kappa_t q_t l_{t+1}$$

- Financial innovation implies change from an environment with a constant κ^l to a regime with two possible LTVs

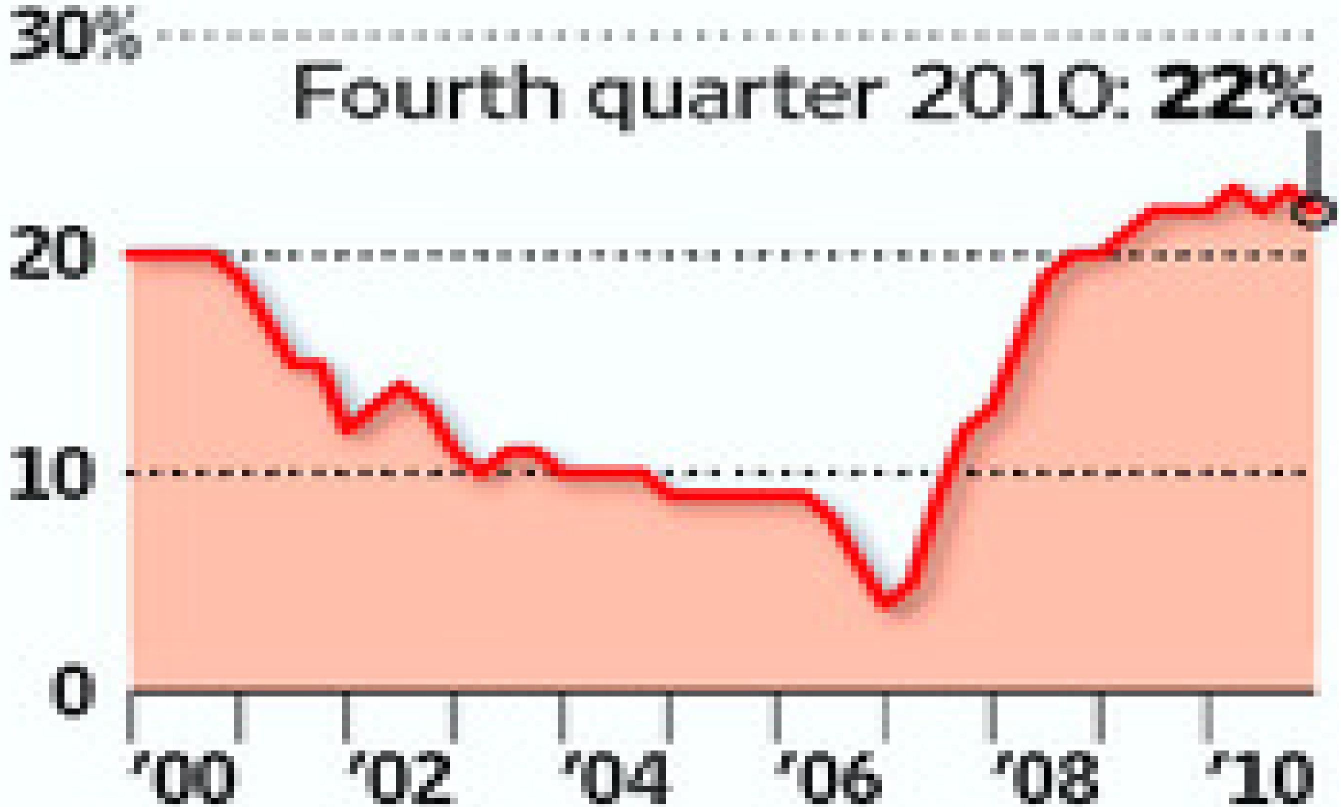
$$\kappa^l < \kappa^h$$

- Risk of this new financial environment is unknown (transition probabilities $F^s{}_{hh}$, $F^s{}_{ll}$ are unknown)
- Empirical relevance:
  - Roughly 1/3rd of credit booms follow financial innovation
  - 2008 U.S. crash preceded by large legal/regulatory changes and introduction of new products (securitization boom)

U.S. financial innovation timeline

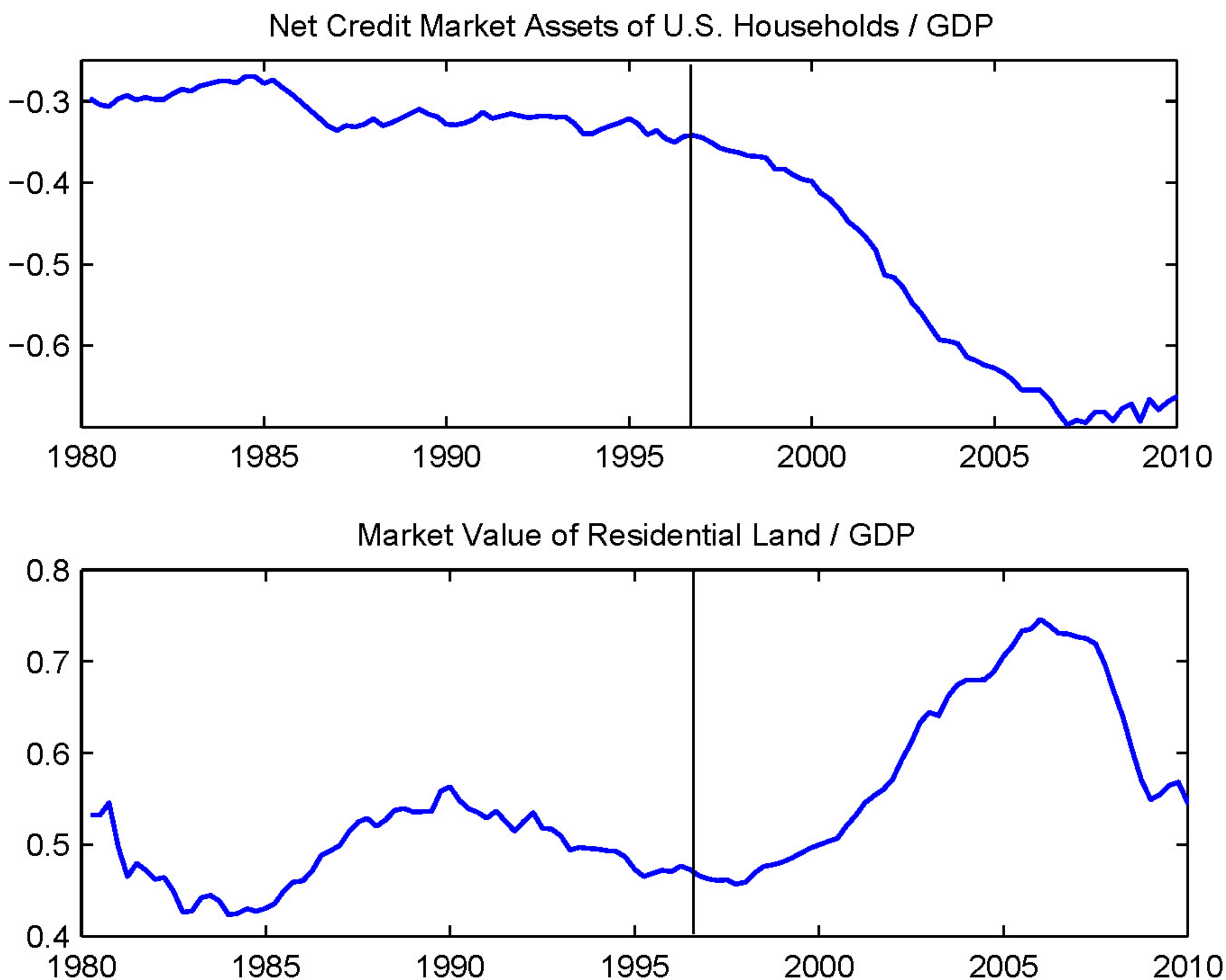
- **2010** Dodd-Frank Wall St. Reform Act
- **2008** Net credit assets-GDP bottoms
- **2006** Peak of stock & housing markets
- **2005** CDSs on MBS
- **2000** Com. Fut. Modernization Act
- **1999** Gramm-Leach-Bliley Act
- **1997** First CDS
- **1996** Net credit assets start ⇓
- **1995** New Community Reinvest. Act
- **1987** First CDO

Median LTV on conventional mortgages



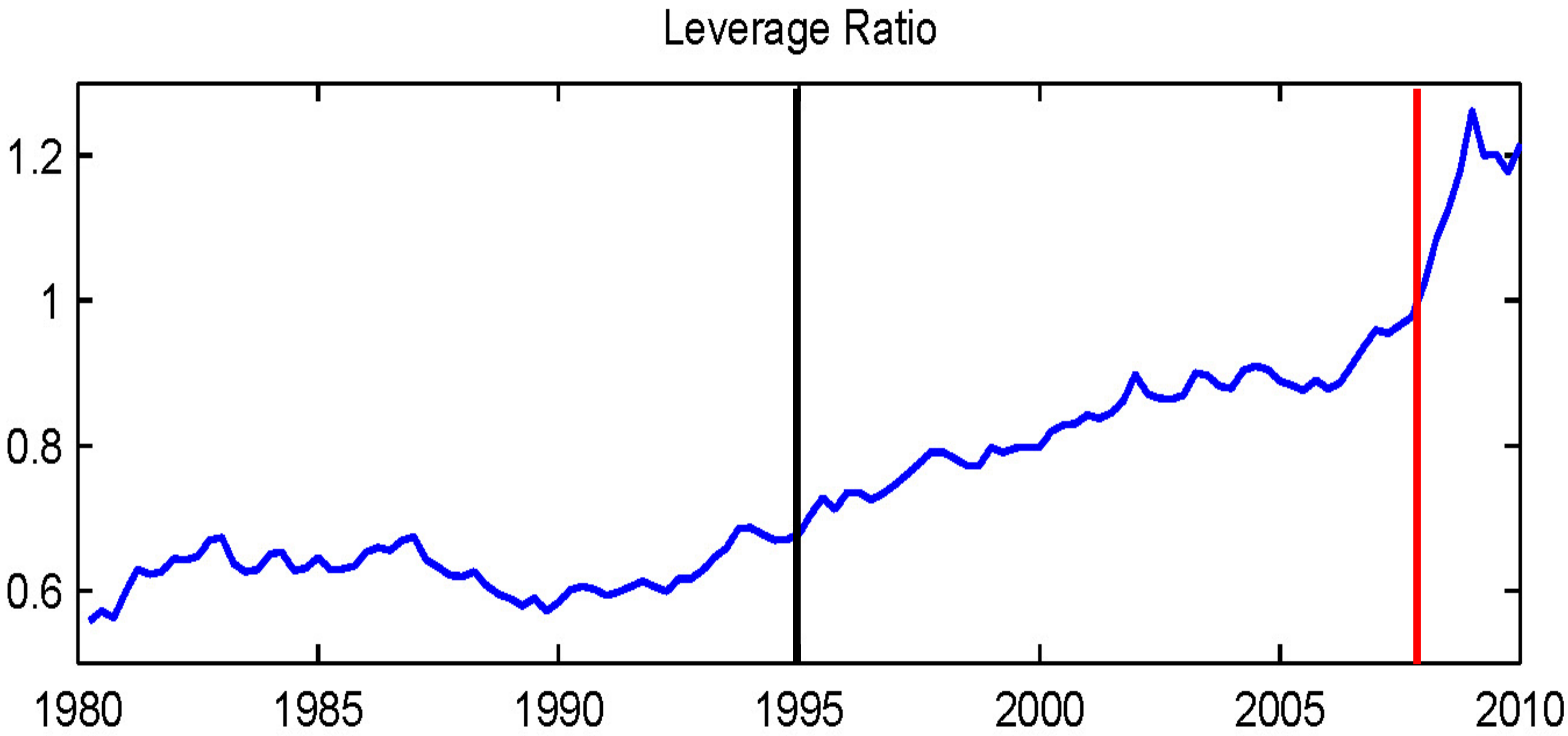
*Weighted average of median down payment percentage in nine metro areas

The U.S. Boom and Bust



U.S. Household leverage ratio

(net credit market assets as a share of the market value of residential land)



Beliefs and (Bayesian) discovery of risk

1. Agents learn as they observe financial regimes, applying Bayes rule over Beta-Binomial distributions

2. Regime transition counters

$$n_{t+1}^{ij} = \begin{cases} n_t^{ij} + 1 & \text{if } \kappa_{t+1} = \kappa^j \text{ and } \kappa_t = \kappa^i, \\ n_t^{ij} & \text{otherwise.} \end{cases}$$

3. Initial priors n_0^{ij} (lower the “newer” the regime)

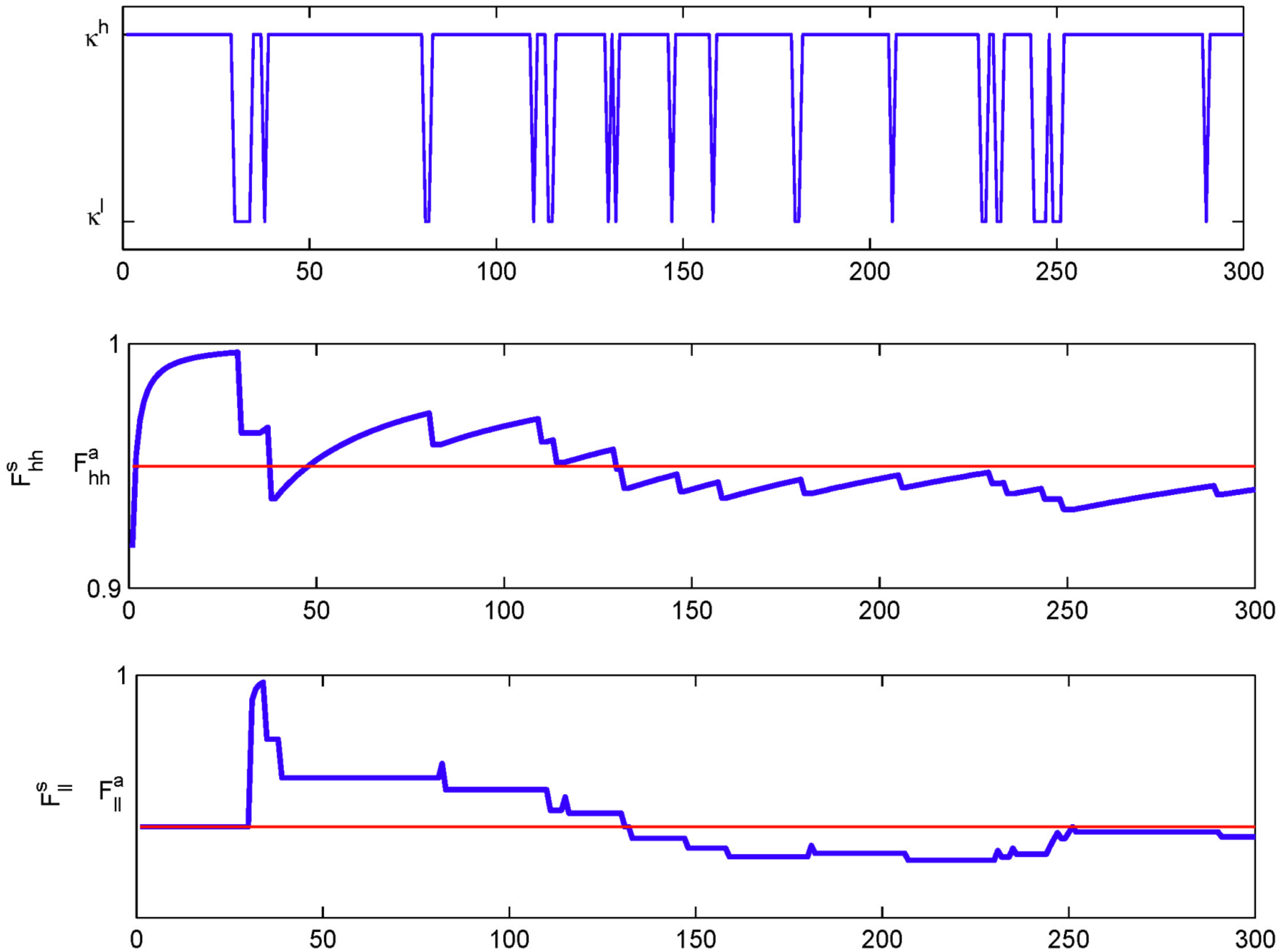
4. Beta-binomial mean posteriors (“beliefs”):

$$E_t[F_{hh}^s] = \frac{n_t^{hh}}{n_t^{hh} + n_t^{hl}} \qquad E_t[F_{ll}^s] = \frac{n_t^{ll}}{n_t^{ll} + n_t^{lh}}$$

Main features of the learning process

1. Convergence to true probabilities in the long run
2. Beliefs about a regime updated only when observing it
3. Initial priors drive speed at which optimism builds with financial innovation
   – With low (uninformative) priors, short initial spell of good credit regime leads to highly optimistic beliefs
4. Optimistic beliefs induce optimistic asset pricing, leading collateral constraint to bind in upswing of credit boom

Example of learning dynamics



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

Decentralized equilibrium

$$E_0^s \left[\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma} \right]$$

s.t.:

$$c_t = z_t g(l_t) + q_t l_t - q_t l_{t+1} - \frac{b_{t+1}}{R} + b_t$$

$$\frac{b_{t+1}}{R} \geq -\kappa_t q_t l_{t+1}$$

- Expectations now depend on agents' beliefs
- Aggregate supply of land is fixed
- Two-stage solution based on Anticipated Utility (Bayesian learning but not Bayesian optimization)

Asset pricing and beliefs

- Excess returns

$$E_t^s\left[R_{t+1}^q - R\right] = \frac{(1-\kappa_t)\mu_t - cov_t^s(\lambda_{t+1}, R_{t+1}^q)}{E_t^s\left[\lambda_{t+1}\right]}$$

$$R_{t+1}^q \equiv \frac{z_{t+1}g'(1) + q_{t+1}}{q_t}$$

- Pricing condition:

$$q_t = E_t^s\left[\sum_{j=0}^{\infty}\left(\prod_{i=0}^{j}\left(\frac{1}{E_t^s[R_{t+1+i}^q]}\right)\right)z_{t+1+j}g'(1)\right]$$

Effects of beliefs if the constraint binds

- Optimism about the "good" regime reduces premia and increases land prices

$$E_t[F^s_{hh}] > F^a_{hh}$$

$$E^s_t[R^q_{t+1}|\kappa_t = \kappa^h, \mu_t > 0] < E^a_t[R^q_{t+1}|\kappa_t = \kappa^h, \mu_t > 0]$$

- Pessimism about the "bad" regime increases premia and lowers land prices

$$E_t[F^s_{ll}] > F^a_{ll}$$

$$E^s_t[R^q_{t+1}|\kappa_t = \kappa^l, \mu_t > 0] > E^a_t[R^q_{t+1}|\kappa_t = \kappa^l, \mu_t > 0]$$

Recursive eq. conditions with Anticipated Utility

$$u'(c_t(\eta)) = \beta R \left[\sum_{z' \in Z} \sum_{\kappa' \in \{\kappa^h, \kappa^l\}} \boxed{E_t^s[\kappa'|\kappa]} \pi(z'|z) u'(c_t(\eta')) \right] + \mu_t(\eta)$$

$$q_t(\eta)(u'(c_t(\eta)) - \mu_t(\eta)\kappa) =$$

$$\beta \left[\sum_{z' \in Z} \sum_{\kappa' \in \{\kappa^h, \kappa^l\}} \boxed{E_t^s[\kappa'|\kappa]} \pi(z'|z) u'(c_t(\eta')) \left(z' g'(1) + q_t(\eta') \right) \right]$$

$$c_t(\eta) = z g(1) - \frac{b_t'(\eta)}{R} + b$$

$$\frac{b_t'(\eta)}{R} \geq -\kappa q_t(\eta) 1$$

$$\text{where} \quad \boxed{E_t^s[\kappa'|\kappa] \equiv \begin{bmatrix} E_t[F_{hh}^s] & 1 - E_t[F_{hh}^s] \\ 1 - E_t[F_{ll}^s] & E_t[F_{ll}^s] \end{bmatrix}.}$$

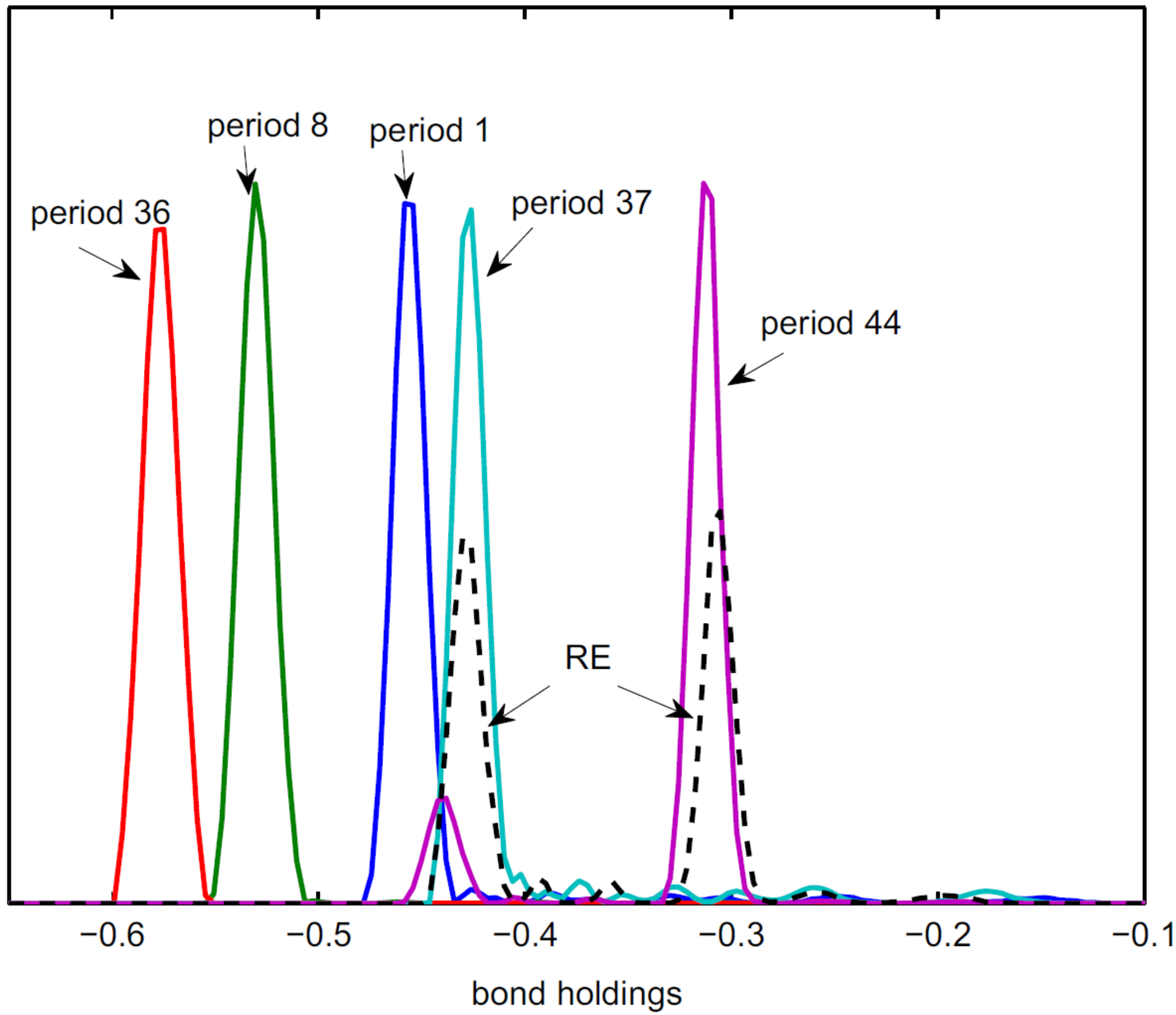
Quantitative analysis: Financial Innovation Experiment

- Pre-financial innovation: Before 1998, regime with constant κ^l stochastic TFP
- Financial Innovation: 1998Q1, introduce regime with κ^h, κ^l and first realization of κ^h
  - Start of sharp decline in net credit assets-GDP ratio
  - Early stages of trading in securitized mortgage instruments under CRA
- Financial crisis: 2007Q1, first realization of κ^l
  - Early stages of subprime mortgage crisis
  - First year of correction in housing prices
- Learning period of T=44 quarters, first 36 with "good" credit regime, remaining 8 with "bad" credit regime
  - 24% percent probability using calibrated "true" process of credit regimes

U.S. Calibration

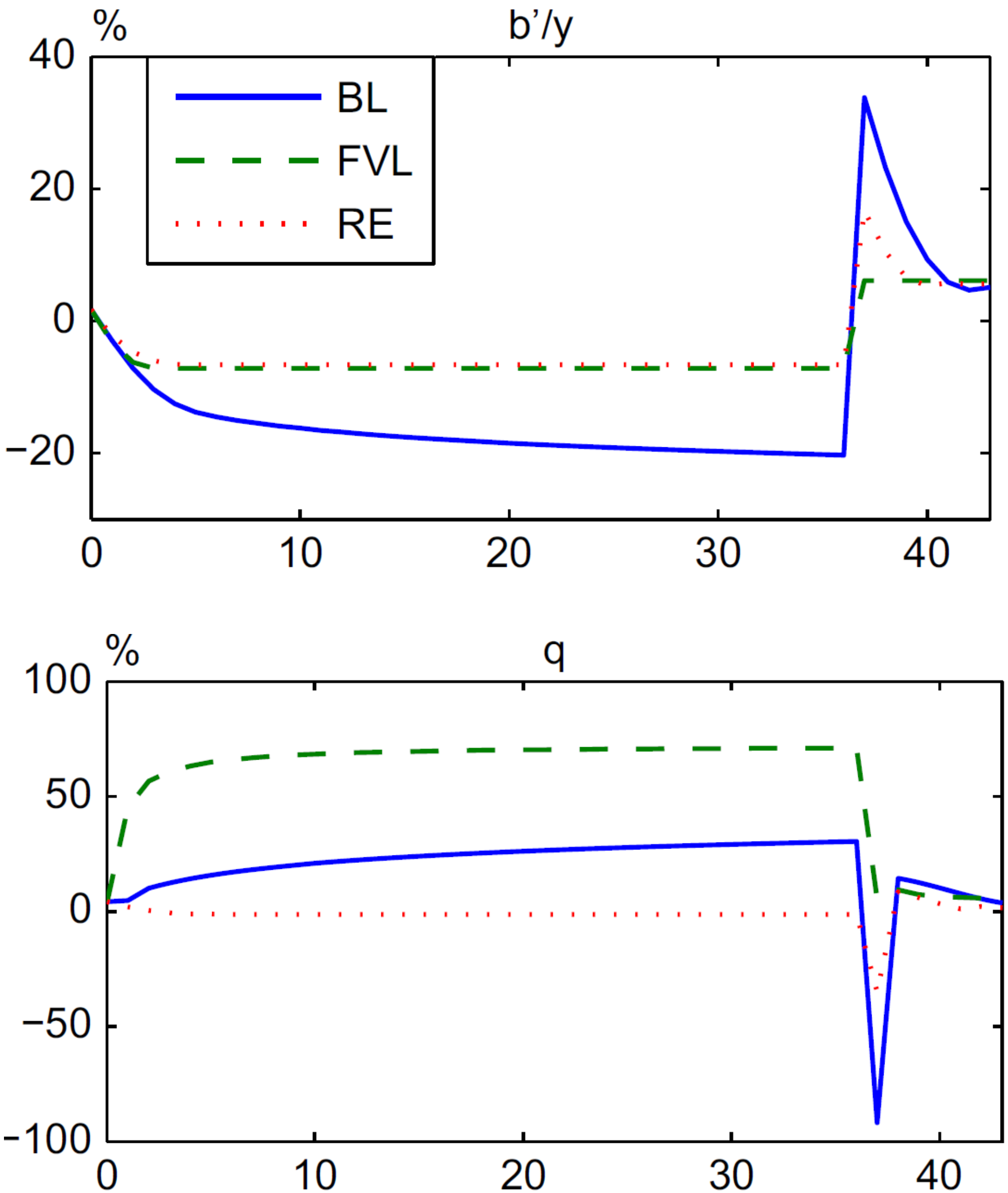
β	Discount factor (annualized)	0.91
σ	Risk aversion coefficient	2.0
c	Consumption–GDP ratio	0.668
A	Lump-sum absorption	0.322
r	Interest rate (annualized)	2.702
ρ	Persistence of endowment shocks	0.878
σ_e	Standard deviation of TFP shocks	0.007
α	Factor share of land in production	0.026
L	Supply of land	1.0
κ^h	Value of κ in the high securitization regime	0.926
κ^l	Value of κ in the low securitization regime	0.629
F^a_{hh}	True persistence of κ^h	0.964
F^a_{ll}	True persistence of κ^l	0.964
n^{hh}_0, n^{hl}_0	Priors	0.014

Optimism weakens self-insurance incentives

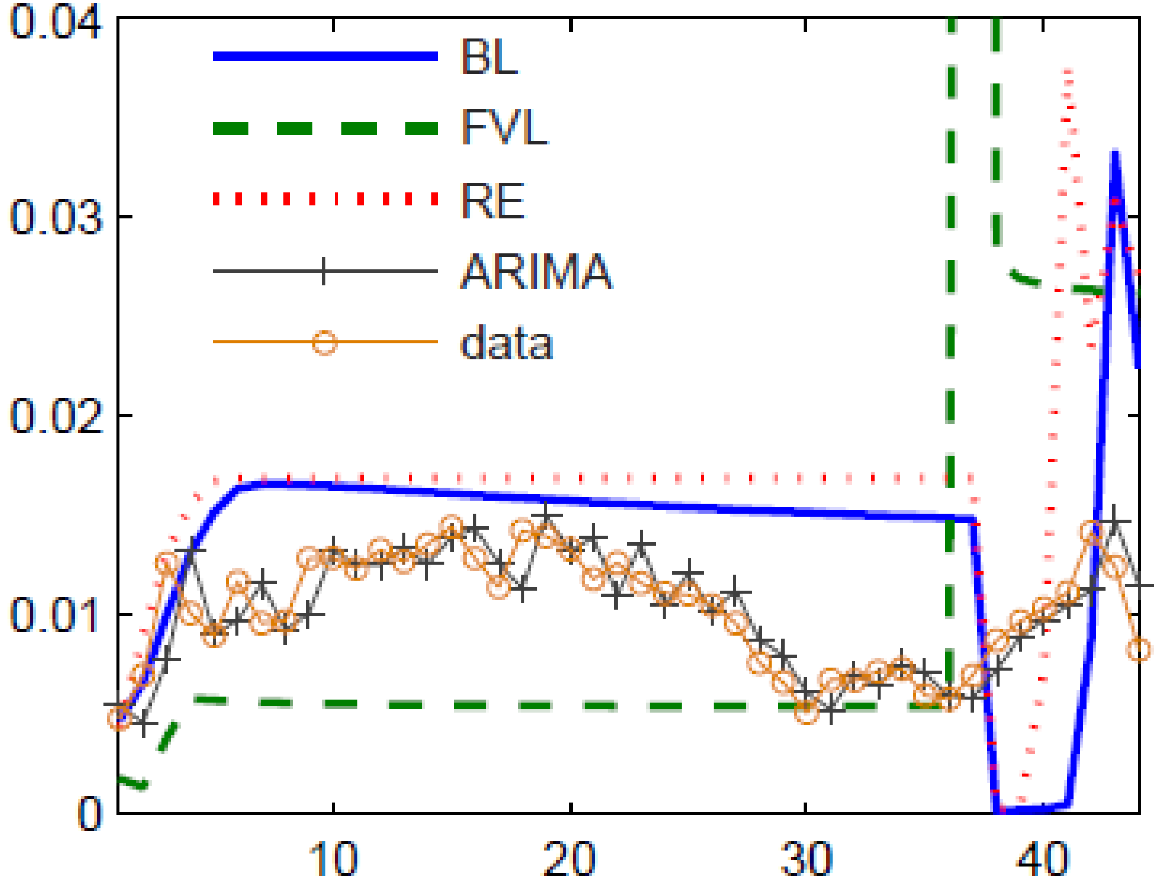


Perceived long-run distributions of bond holdings

Dynamics of debt and land prices



Expected excess returns



Booms and busts in U.S. data & model

Period	(1) Data	(2) RE	(3) FVL	(4) BL
Peak of optimism:				
$E[(b/y)_{36} - (b/y)_0]$	−0.334	−0.065	−0.071	−0.213
$E[(ql/y)_{36} - (ql/y)_0]$	0.267	−0.025	0.306	0.131
Financial crisis:				
$E[(b/y)_{44} - (b/y)_{36}]$	0.023	0.122	0.133	0.262
$E[(ql/y)_{44} - (ql/y)_{36}]$	−0.149	0.013	−0.301	−0.130

- Bayesian learning (BL) model can explain 64 (49) percent of rise in U.S. household debt (land prices)
- Strong Fisherian interaction of discovery of risk with debt-deflation mechanism

MPP implementation challenges

- Informational frictions strengthen financial amplification
- Financial innovation is a perennial process, so belief-driven cycles are also recurrent
- Informational frictions affect agents and regulators:
  - Are regulators more or less informed? (in 2008 crash regulators were less informed)
  - Bianchi, Boz & Mendoza (12) show that when regulators are as uninformed as private agents MPP is ineffective, v. when they knows true riskiness of new regime MPP is very active (taxing overborrowing to tackle externality and optimistic asset pricing)
- Complexity and lack of credibility (time inconsistency)
- Heterogeneity of borrowers and lenders
- Coordination with monetary policy and across counties