Understanding Financial Crises: Quantitative Lessons from Fisherian Models

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2018 Annual Meeting of the Society for Economic Dynamics
ITAM, Mexico City, June 28, 2018

Motivation

*It is not good enough to argue that the canonical model works in normal times. We need also to understand the risks of crises and what to do about them…**A macroeconomics that does not include the possibility of crises misses the essential**, just as would a medicine that assumes away the possibility of heart attacks.*

Martin Wolf, FT, 3/20/2018

…but good medicine needs good science

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****…*

Robert Merton, Muh Award Lecture, 03/05/2009

Key questions of “crisis medicine”

1. What are the facts that we need to explain?

2. Can models of financial crises explain them?

3. If so, what are their normative implications?

Answers from research on Fisherian models

1. What are the facts that we need to explain?

Frequency and nonlinear characteristics of financial crises in macroeconomic time series.

2. Can models of financial crises explain them?

Fisherian models generate infrequent crises as a result of endogenous financial amplification (debt-deflation).

3. If so, what are their normative implications?

Pecuniary externalities via collateral prices can cause overborrowing. Optimal MPP is effective but complex and time-inconsistent under commitment. Simple rules fail!

Layout of the lecture

1. Stylized facts from Intn'l Macro perspective: Sudden Stops

2. Main features of Fisherian models

3. Positive analysis: Explaining the facts

4. Normative analysis and policy implications

5. Unanswered questions and new frontiers

1. Stylized facts of Sudden Stops

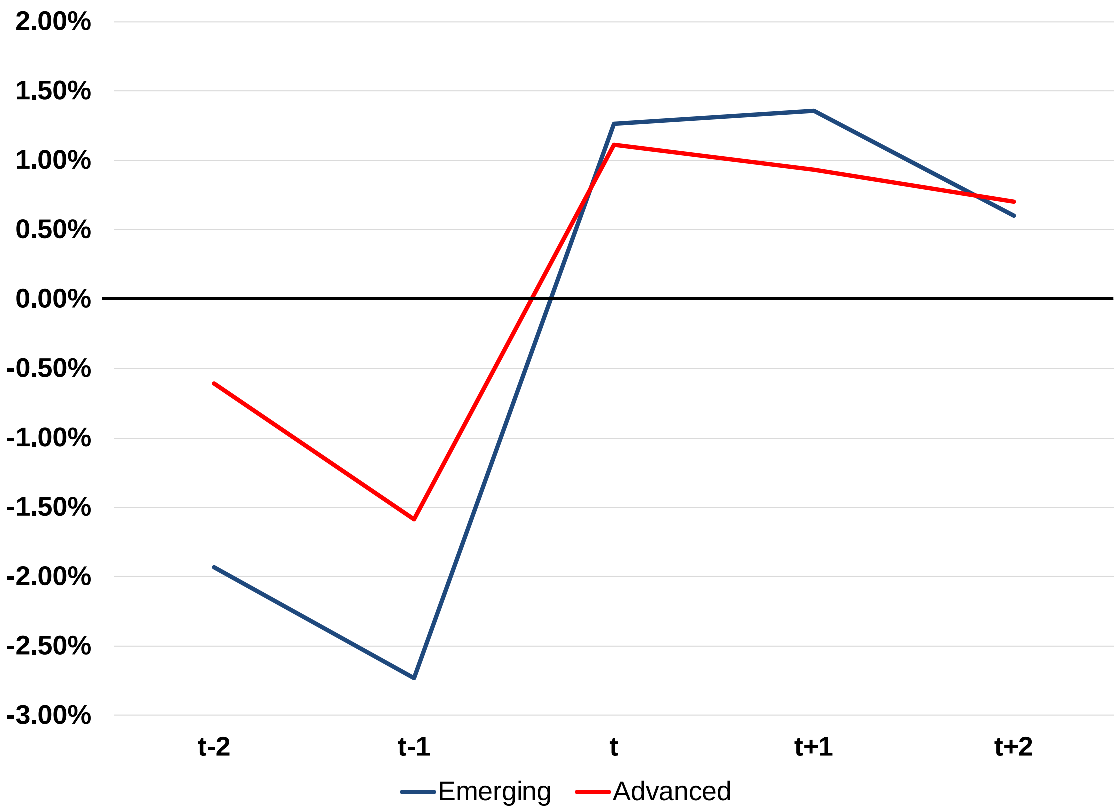
Defining and measuring Sudden Stops

- 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 cyclical components of macro data

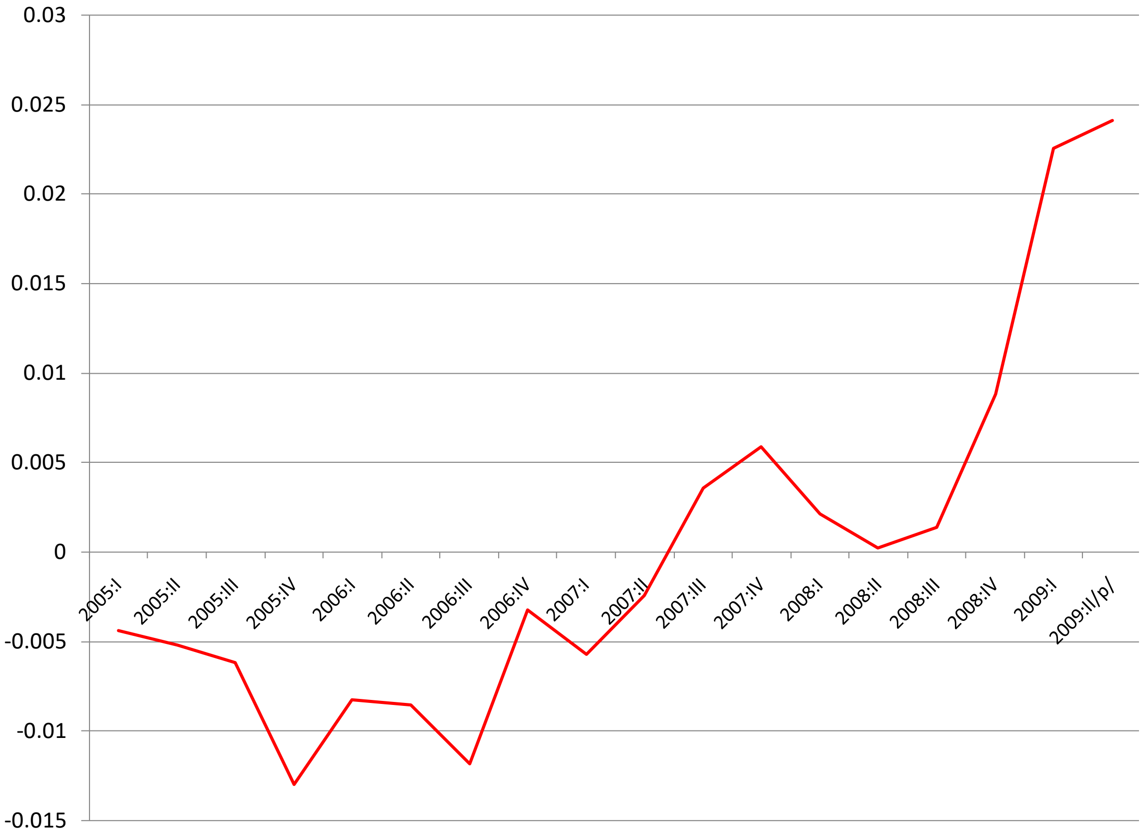
Stylized facts of Sudden Stops

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

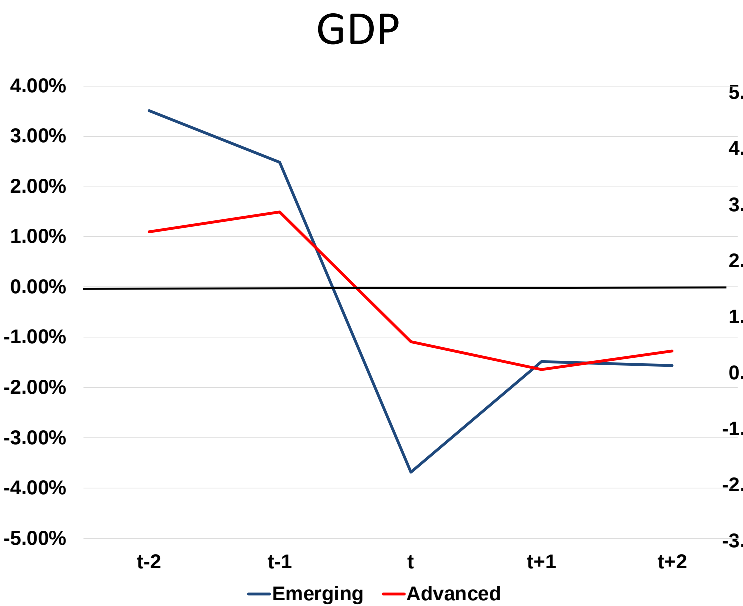
SS events: Current account-GDP ratio

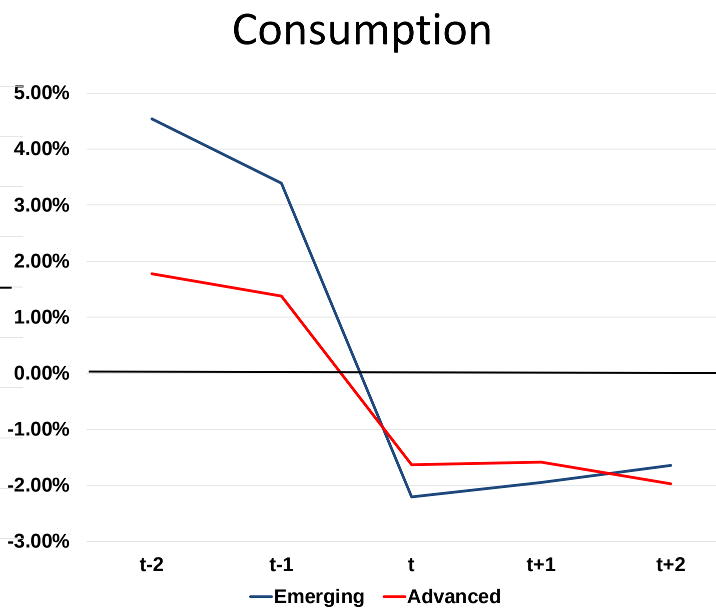


The 2008-2009 U.S. Sudden Stop
(ca/y, deviation from the mean)

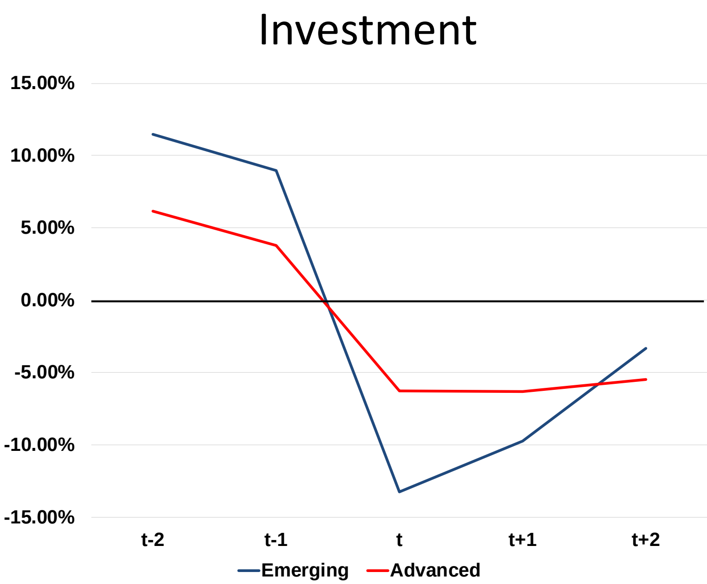


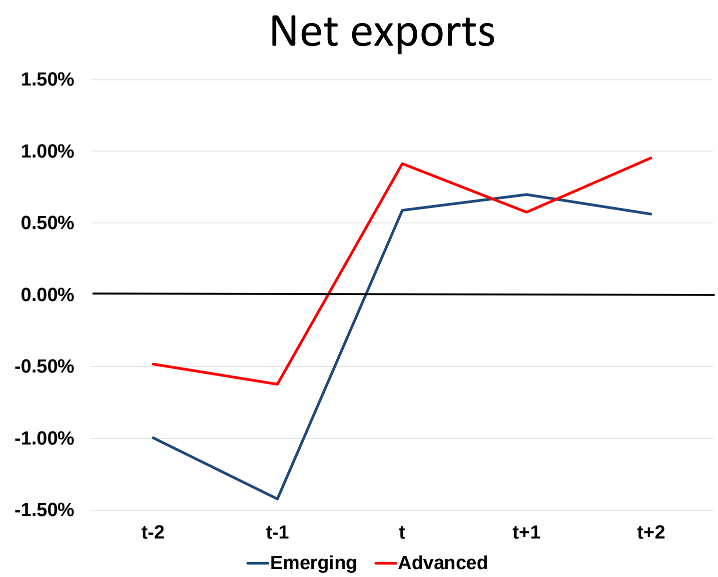
GDP & consumption during Sudden Stops



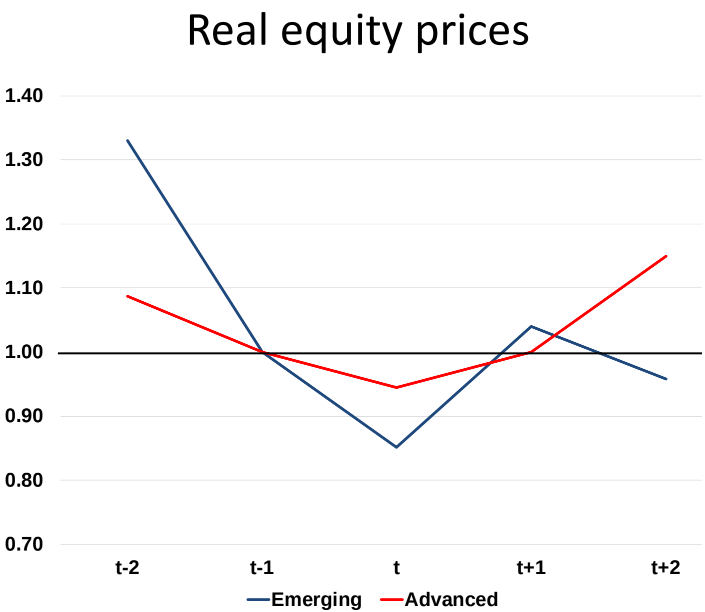


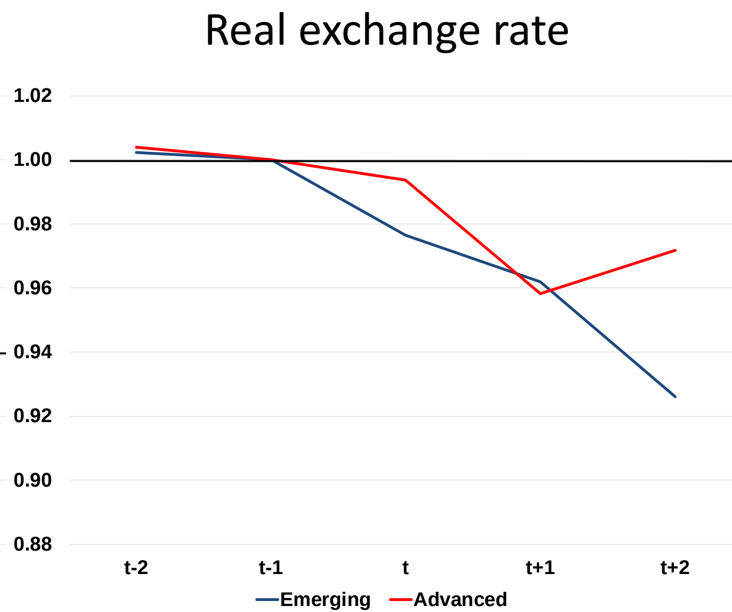
Investment & net exports during Sudden Stops





Equity prices & real ex. rates during Sudden Stops





2. Main features of Fisherian models

Fisherian credit constraints

- Debt cannot exceed a fraction of <u>market value</u> of assets or incomes pledged as collateral (prices affect borrowing capacity):

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

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

- Market prices of collateral are aggregate outcomes: $p_t^N(C_t^T, C_t^N)$, $q_t(C_t, C_{t+1})$

Key implications of Fisherian constraints

1. Debt-deflation mechanism:
   - When constraint binds, agents fire-sale assets/goods, prices fall, constraint tightens further forcing more fire sales
   - Credit crunch triggers collapse in agg. demand
   - Agg. supply also falls via effects on factor demands and/or TFP (e.g. working capital, deflation of marginal products, utilization, misallocation, etc.)

2. Pecuniary externality: agents do not internalize effect of individual borrowing on collateral market prices
   - Dynamic externality: effect of today's borrowing on tomorrow's prices if a crisis occurs
   - A planner can increase social welfare by altering borrowing in "good times" (macroprudential regulation)

Important remarks

- Collateral constraint is occasionally binding, depending on agents' choices and market prices
- In Fisher (1933), innovation and beliefs interact with debt-deflation mechanism
- Endogenous crises triggered by standard shocks (not large, unexpected shocks or financial shocks)
- Examples: Kiyotaki-Moore, Bernanke-Gertler, Lorenzoni, Aiyagari-Gertler, Brunnermeier-Sannikov,…
- Solutions require global methods (nonlinearities, prec. savings), existing local methods are inaccurate and inefficient (Durdu et al. (18))
- Multiplicity can occur at high κ_t, low elasticities of substitution, and shocks in the "right" interval

3. Explaining Sudden Stops

Survey of applications & findings

- DTI models: Mendoza (01,02), Bianchi (11), Korinek (11), Durdu et al. (09), Bianchi et al. (16), Benigno et al. (13,16), Schmitt-G. & Uribe (17), Korinek & Mendoza (14),…
- LTV models: Durdu & Mendoza (06), Devereux & Yu (16), Mendoza & Smith (06,14), Mendoza (10), Jeanne & Korinek (10), Mendoza & Quadrini (10), Schmitt-G. & Uribe (18), Bianchi & Mendoza (18),…
- Quantitative findings:
  1. Large amplification in response to standard shocks (TFP, TOT, interest rates, news, etc)
  2. Endogenous, infrequent financial crises w. deep recessions, large CA reversals and price collapses
  3. Crises nested within realistic business cycles

Real business cycles with a Sudden Stop

(Mendoza AER, 2010)

- Workhorse RBC-SOE model (Neumeyer & Perri (06), Uribe & Yue (06)), with shocks to input prices, interest rates and TFP measured from data
- Budget constraint of representative firm-household:

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

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

- Collateral constraint on debt and working capital

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

- Mendoza & Villalvazo (18) provide simple, fast algorithm

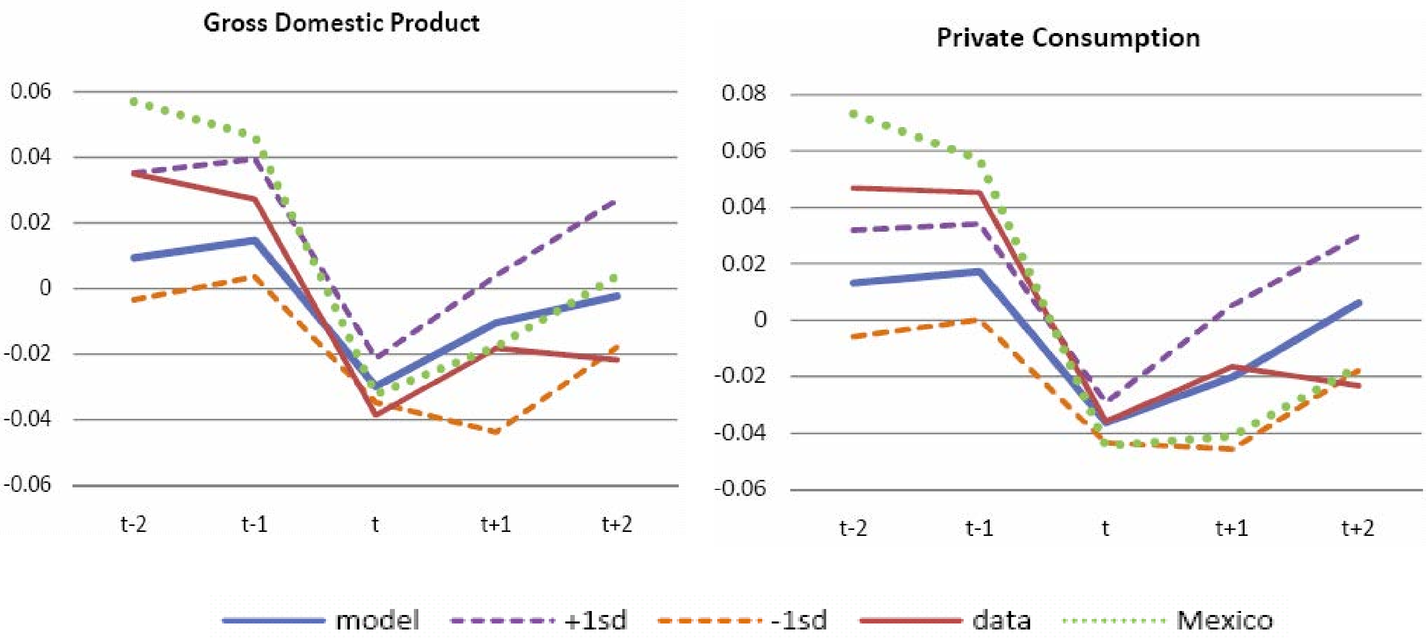
Amplification & Asymmetry in Crises

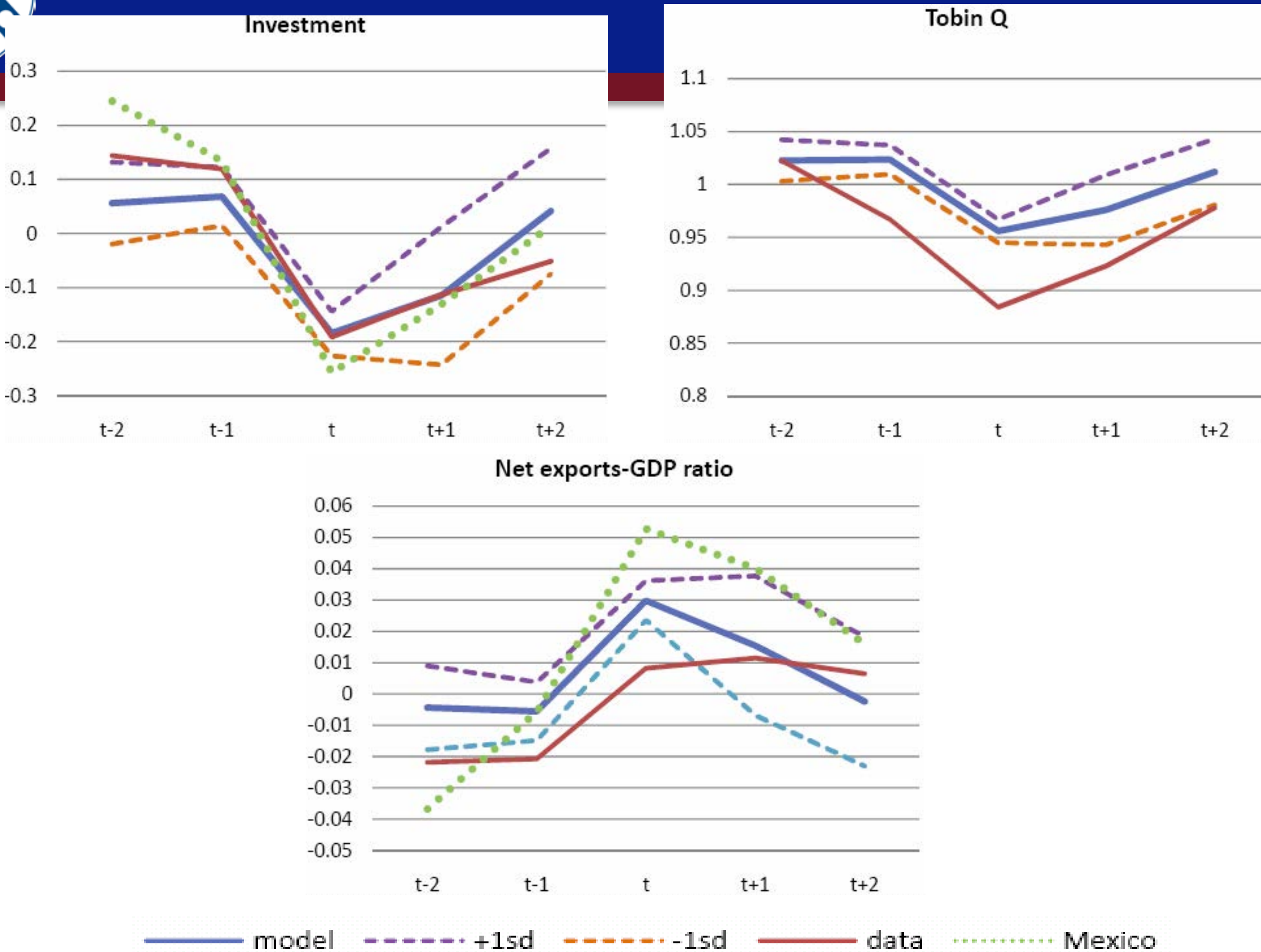
(mean excess responses relative to frictionless economy in percent of frictionless averages)

	S.S. states	non S.S. states
gdp	-1.13	-0.11
c	-3.25	-0.31
i	-11.84	-0.61
q	-2.88	-0.15
nx/gdp	3.56	0.25
b/gdp	3.57	0.25
lev. ratio	1.31	0.12
L	-1.71	-0.16
v	-3.10	-0.29
w. cap.	-3.12	-0.29
prob. of SS events	3.32%	
b/gdp in SS events	-0.21	

Note: Baseline calibration to Mexican data (with κ =0.2)

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

4. Normative Implications

Macroprudential pecuniary externality

- Euler eq. for bonds 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 regulator (constrained-eff. planner):

$$u'(t) = \beta R_t E\left[u'(t+1) + \mu^*_{t+1}\kappa_{t+1} f'(t+1)\frac{\partial p_{t+1}}{\partial \tilde{C}_{t+1}}\frac{\partial \tilde{C}_{t+1}}{\partial b_{t+1}}\right]$$

- Agents choose debt in "good times" ignoring price responses in "crisis times"
- If social MC of debt > private MC, agents borrow more than what is socially optimal (overborrowing)

Proving social MC of debt *is* higher

- Higher social MC of debt requires:

$$f'(t+1)(\partial p_{t+1}/\partial \tilde{c}_{t+1})(\partial \tilde{c}_{t+1}/\partial b_{t+1}) > 0$$

- These are trivially positive: borrowing capacity rises with collateral values, consumption rises with wealth

- But the sign of this is a key endogenous equilibrium outcome, which can be proven to be positive:

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

- Optimal “macroprudential debt tax:”

$$\tau_t = \frac{E_t\left[\mu^*_{t+1}\kappa_{t+1} f'(t+1)\frac{\partial p_{t+1}}{\partial \tilde{C}_{t+1}}\frac{\partial \tilde{C}_{t+1}}{\partial b_{t+1}}\right]}{E_t\left[u'(t+1)\right]}$$

  – $\tau_t > 0$ only if $E_t[\mu_{t+1} > 0]$

- Equivalent instruments: capital requirements (Bianchi 11), regulatory LTV, DTI ratios
- But NOT a case for capital controls: domestic debt taxes also equivalent (Mendoza & Rojas (18)), no case for discriminating foreign v. domestic credit

Application to an LTV model
(Bianchi & Mendoza, JPE 2018)

- Like RBC model but capital in fixed supply

$$\max \quad \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t u(c_t - G(n_t)) \right]$$

$$u(c_t - G(n_t)) = \frac{\left(c_t - \chi \frac{h^{1+\omega}}{1+\omega} \right)^{1-\sigma}}{1-\sigma}$$

s.t.

$$q_t k_{t+1} + c_t + \frac{b_{t+1}}{R_t} = q_t k_t + b_t + \left[z_t k_t^{\alpha k} m_t^{\alpha m} h_t^{\alpha h} - p^m m_t \right] \quad (\lambda_t)$$

$$\frac{b_{t+1}}{R_t} - \theta p^m m_t \geq -\kappa_t q_t k_t, \quad (\mu_t)$$

Commitment & time consistency

- Same externality when μ_t =0, $E_t[\mu_{t+1}$ >0]
- When μ_t >0, the planner views effects of choosing b_{t+1} on C_{t+1}, q_t differently depending on ability to commit:

1. <u>Commitment</u>*:* 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

2. <u>Discretion</u>*:* The planner of date t considers how its choices affect choices of the planner of t+1 => Markov stationarity (Klein et al. (07,08))

Time inconsistency in DTI models

- Mendoza & Rojas (18) introduce intermediation of dollar inflows into peso loans into DTI model
- Expected RER determines ex-ante interest rate, actual RER alters ex-post repayments
- Time inconsistency: planner pledges higher future RER to lower interest rates, but ex-post prefers lower RER to lower repayments
- Under commitment, capital controls are still equivalent to domestic debt taxes

Time-consistent Planner's problem

$$V(b,\varepsilon) = \max_{c,b',h,m} \left[\frac{\left(c - \chi \frac{h^{1+\omega}}{1+\omega}\right)^{1-\sigma}}{1-\sigma} + \beta E\big[V(b',\varepsilon')\big] \right]$$

s.t.

$$c + \frac{b'}{R} = b + \left[z1^{\alpha k} m^{\alpha m} h^{\alpha h} - p^m m \right]$$

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

$$q u_c \left(c - \chi \frac{h^{1+\omega}}{1+\omega} \right) = \beta E\left[u_c \left(\hat{c}' - \chi \frac{\hat{h}'^{1+\omega}}{1+\omega} \right) \left(z' F_k (1, \hat{m}', \hat{h}') + \hat{q}' \right) + \kappa' \hat{\mu}' \hat{q}' \right]$$

Optimal, time-consistent policy

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

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

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

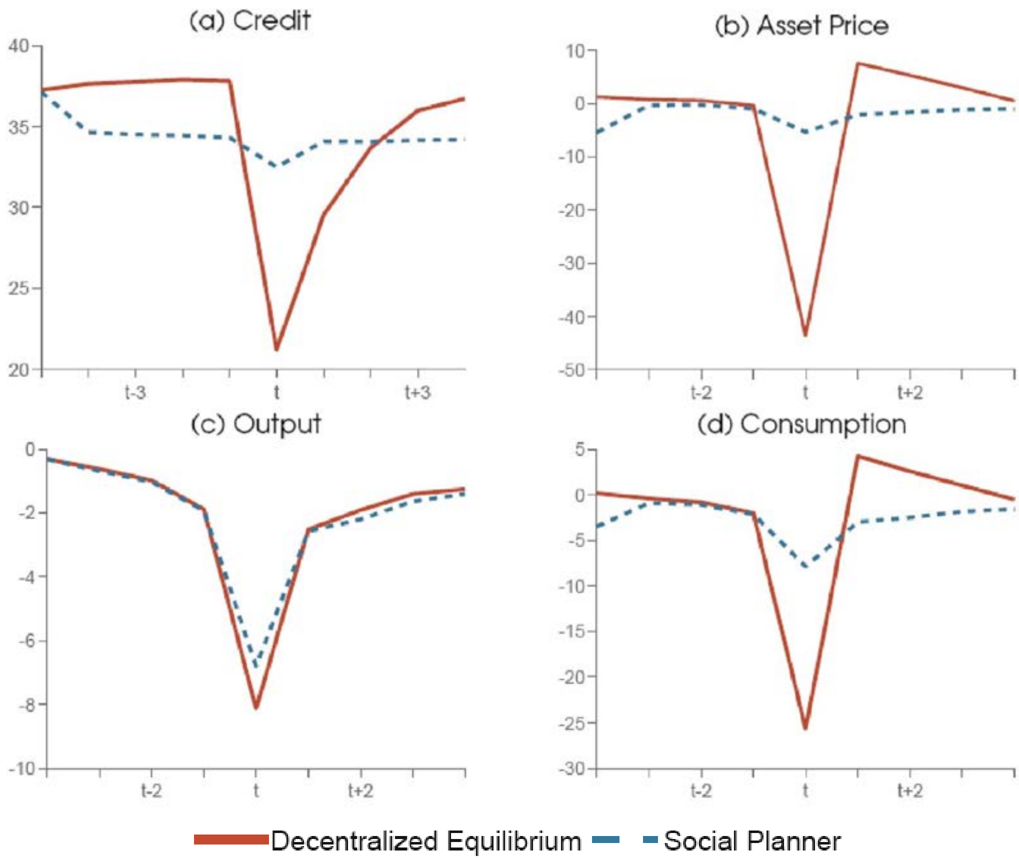
$$\tau_t^{FP} = \frac{E_t\left[\frac{\kappa_t\mu_t^{*}}{u_c(t)}\Omega_{t+1}\right]}{E_t\left[u_c(t+1)\right]} + \frac{\kappa_t\mu_t^{*}\frac{u_{cc}(t)}{u_c(t)}q_t}{\beta R_t E_t\left[u_c(t+1)\right]}$$

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
	$\sigma_R = 1.86\%$	

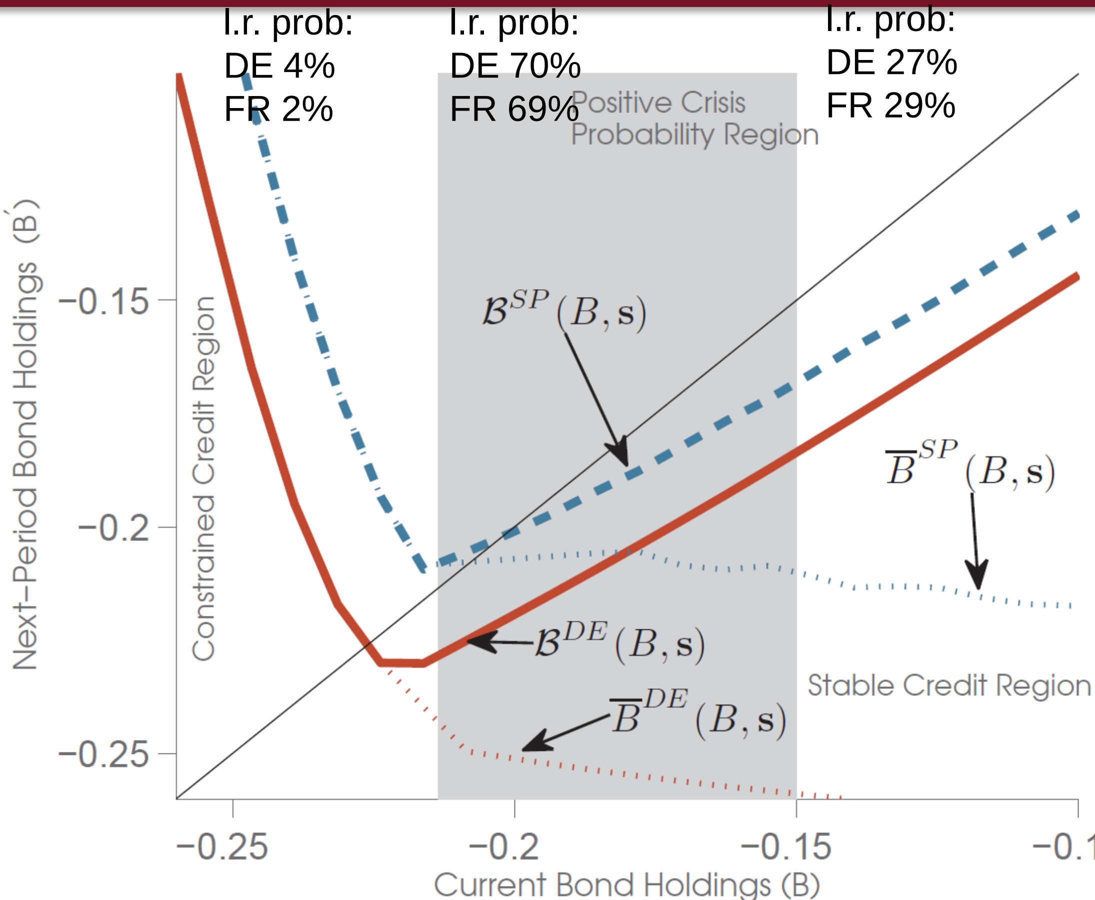
Parameters set by simulation	Value	Target
TFP shock	$\rho_z = 0.78, \sigma_z = 0.01$	GDP sd. & autoc. (OECD average)
Share of assets in gross output	$\alpha_k = 0.008$	Value of collateral matches total credit
Discount factor	$\beta = 0.95$	Private $NFA = -25$ percent
Transition prob. κ^H to κ^L	$P_{H,L}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

Financial crises & policy effectiveness

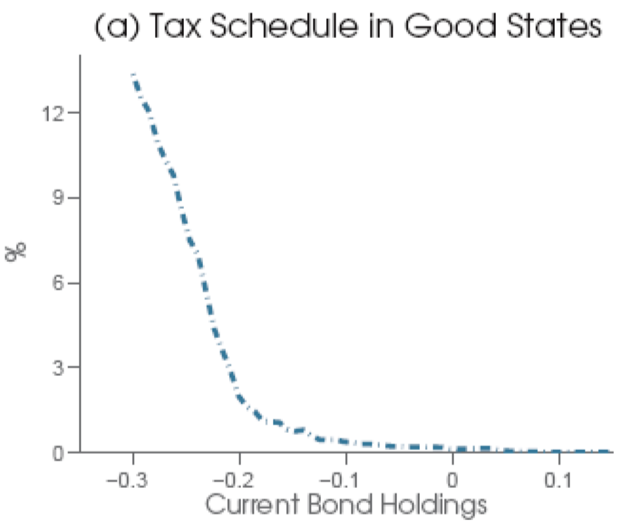


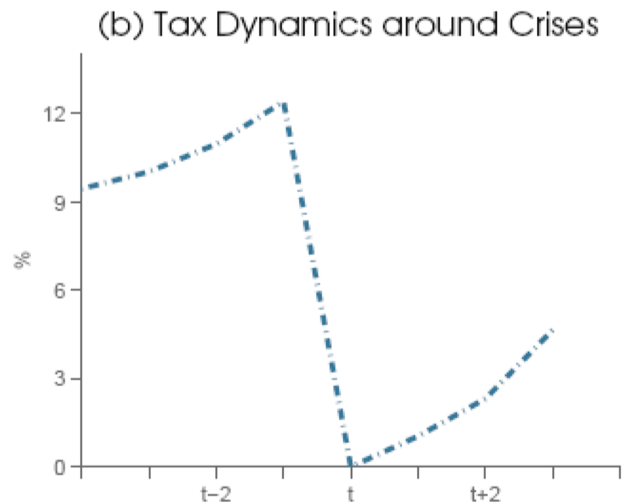
Nonlinear bond decision rules

(low TFP state)



Complexity of the optimal policy



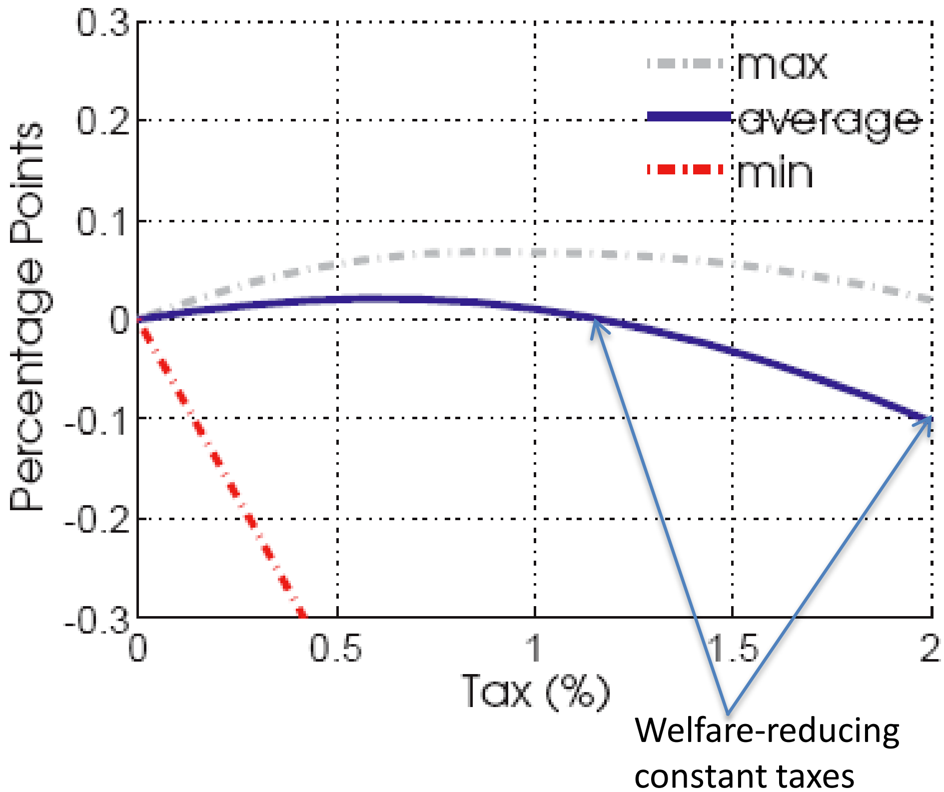


Optimal v. simple policies

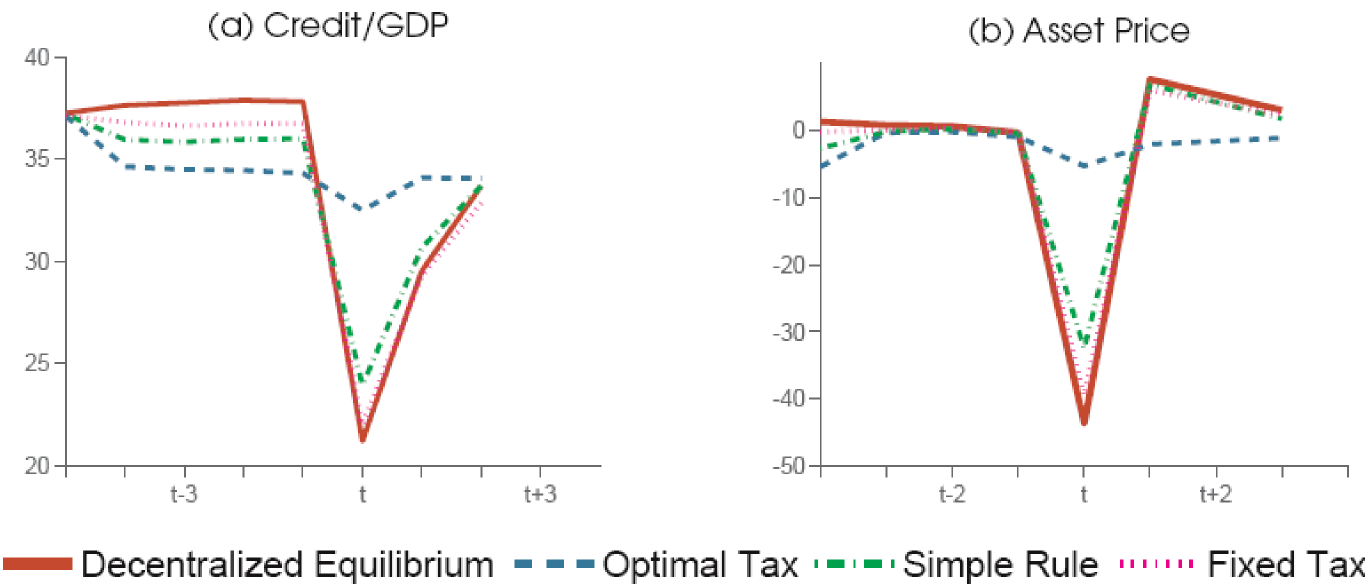
	Decentralized Equilibrium	Optimal Policy	Best Taylor	Best Fixed
Welfare Gains (%)	–	0.30	0.09	0.03
Crisis Probability (%)	4.0	0.02	2.2	3.6
Drop in Asset Prices (%)	−43.7	−5.4	−36.3	−41.3
Equity Premium (%)	4.8	0.77	3.9	4.3
Tax Statistics				
Mean	–	3.6	1.0	0.6
Std relative to GDP	–	0.5	0.2	–
Correlation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

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

Welfare effects of constant taxes



Effects of simple policies on crisis dynamics



5. Unanswered questions & new frontiers

My wish list

1. Explain booms (optimistic beliefs as in Boz & Mendoza (14))
2. Find a simple but effective MPP rule (maybe LTV, DTI ratios)
3. Consider MPP tradeoffs beyond consumption smoothing (investment and durables, growth)
4. Enrich intermediation: informational frictions (Gordon & Ordoñez (14), “liability dollarization” (Mendoza & Rojas (18))
5. Analyze further the value of commitment (Bianchi et al. (18))
6. Introduce meaningful heterogeneity (Hou and Rios-Rull (16))
7. Interactions with other policies (monetary, fiscal, ex. rate) and other sources of inefficient fluctuations (nominal rigidities), as in Carrillo et al. (18), SG & Uribe (16), Farhi & Werning (16)
8. Simpler, faster algorithms (as in Mendoza & Villalvazo (18))