

# FISHERIAN MODELS OF FINANCIAL CRISES IN MACROECONOMICS

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## 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)

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# Financial crises, “Black swans” and nonlinearities

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

- *“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...**”*
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# Layout of the lecture

1. Stylized facts: Financial crises in EMs, credit booms/busts
2. Limitations of the literature & lessons from debt-deflation theory
3. General features of Fisherian debt deflation (DD) models
4. Simple example of amplification & asymmetry w. DD mechanism
5. Quantitative DSGE models
  - a) “New Mercantilism” in emerging markets (surge in reserves)
  - b) International asset trading & portfolio choice
  - c) Business cycles w. endogenous financial crises
6. Conclusions & policy implications
  - a) Creative policies: price guarantees, “macro prudential” policy
  - b) Importance of financial development
  - c) Contagion



# 1. STYLIZED FACTS



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## Financial Crises in EMs: Stylized facts

1. Large, abrupt reversals in capital flows (“Sudden Stops”)
  2. Preceded (followed) by expansions (contractions) in domestic production, absorption, asset prices, credit & leverage
  3. Capital, labor account for small fraction of output drop, compared to imported inputs, capacity utilization, and TFP (Mendoza (06), Meza (08), Calvo et al. (06))
  4. Infrequent events nested within “regular” business cycles
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# Documenting the stylized facts

1. Cross-country event analysis of EMs crises:
    - a) Classification of systemic Sudden Stop events from Calvo et al. (06)
    - b) Capital flows criterion: fall in capital flows exceeding 2sd's
    - c) Spread criterion: spike in aggregate EMBI spread exceeding 2sd's
    - d) 33 SS events in 1980-2004 sample of emerging economies (not excluding "mild output collapse" cases)
    - e) Event windows based on medians of HP detrended data 1970-2004
  2. Event analysis of credit booms in macro and micro data
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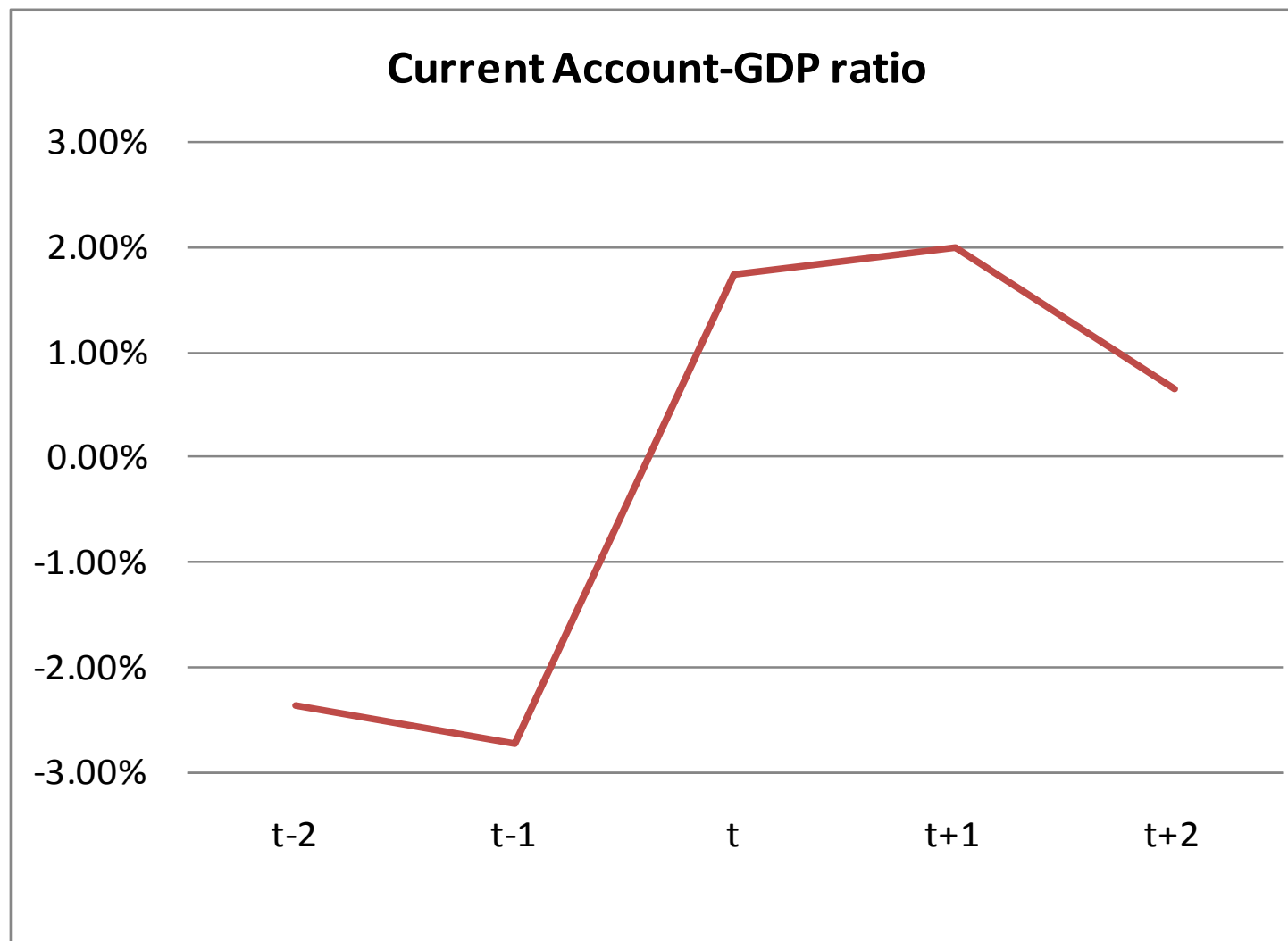
# **Financial Crises in Emerging Markets: Cross-Country Event Analysis**

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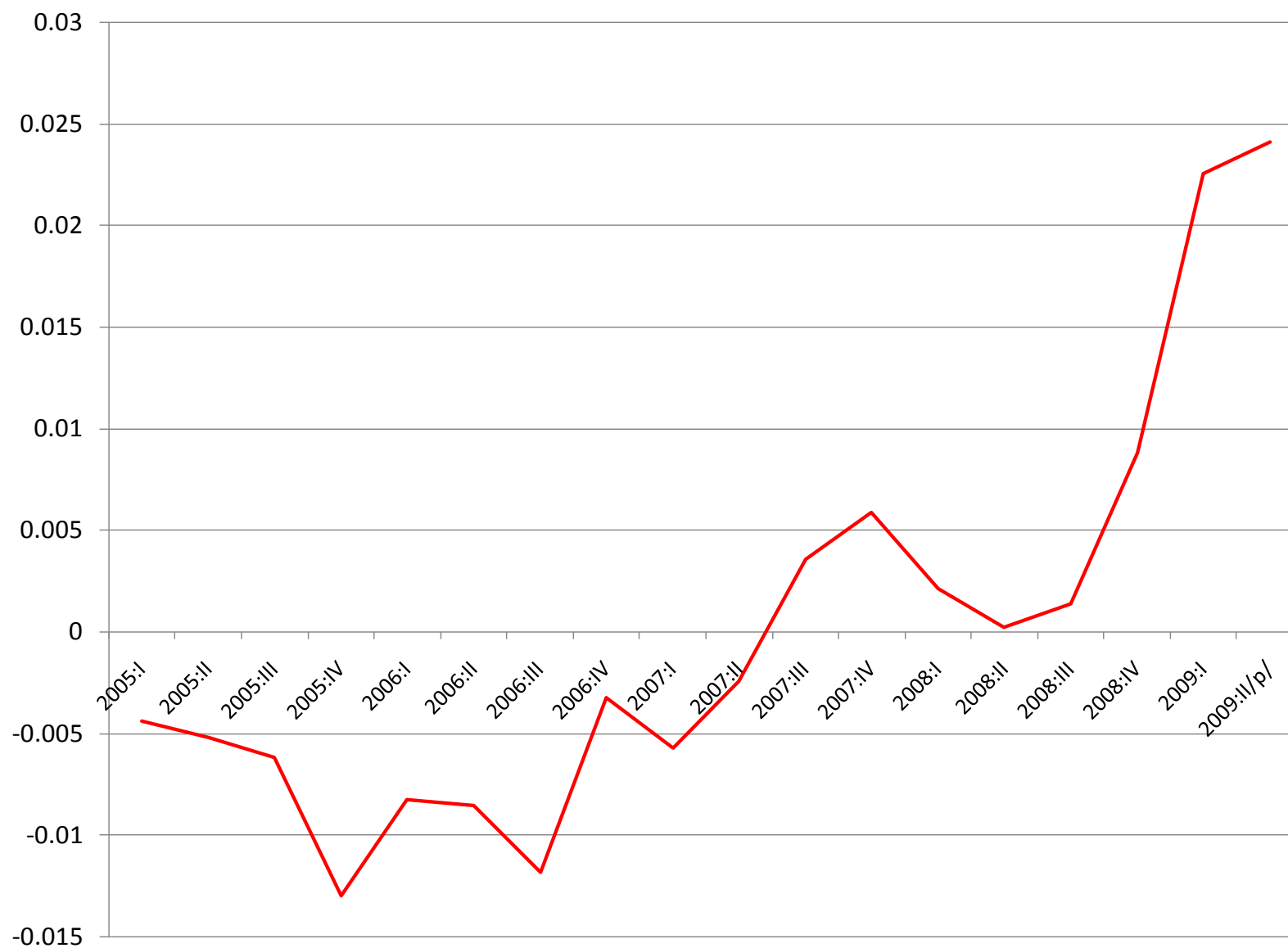


# Current account reversals (Sudden Stop events)

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



# U.S. Current account as a share of GDP (deviation from mean)



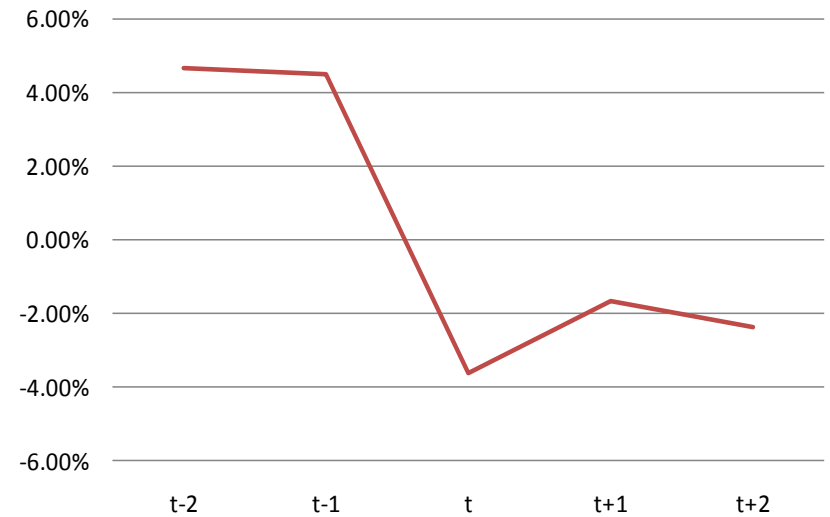
# Output and Consumption collapses

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

**Gross Domestic Product**

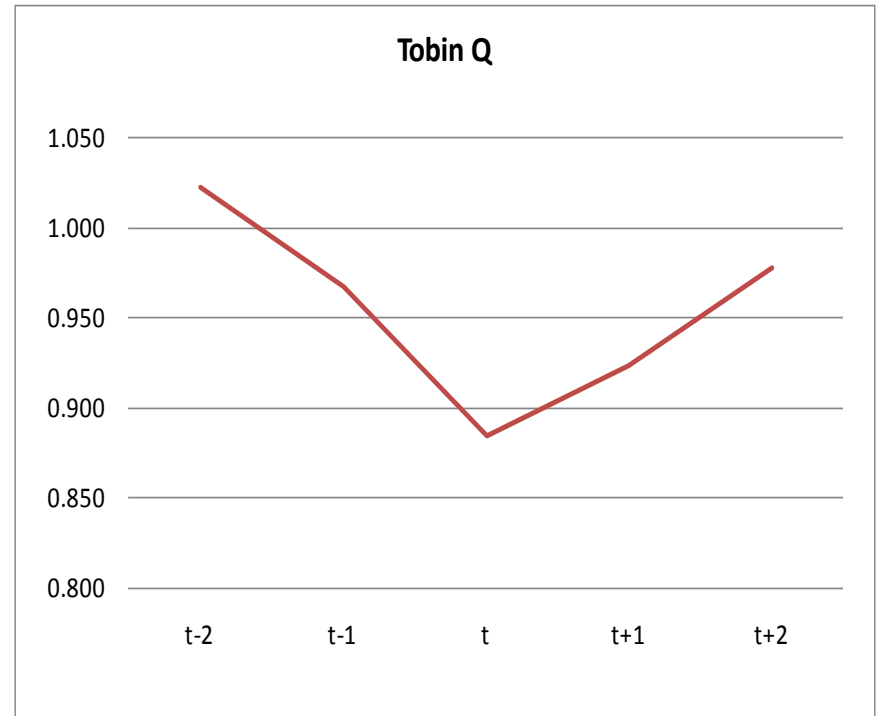
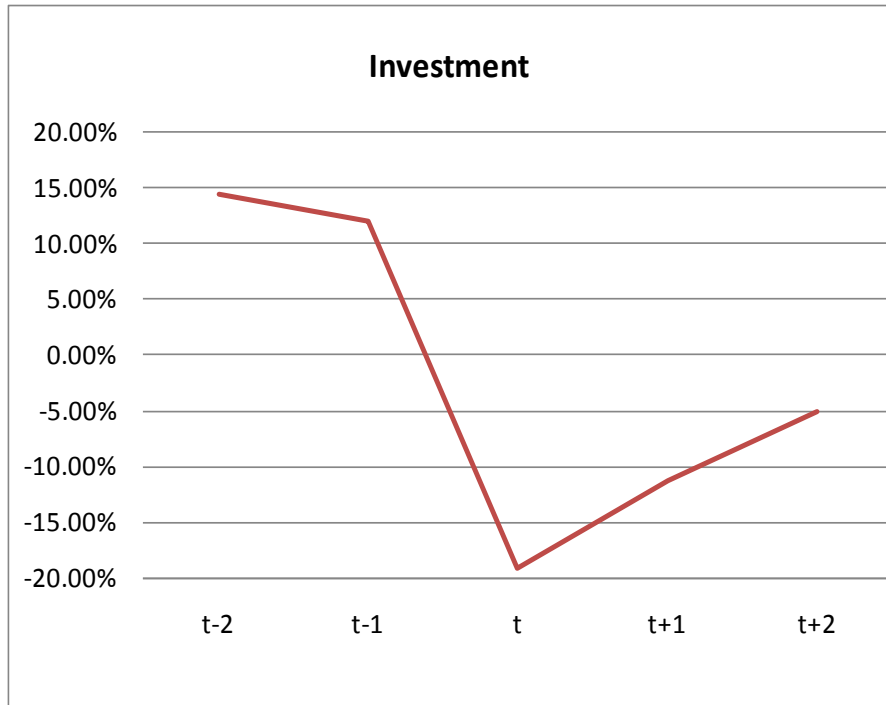


**Private Consumption**



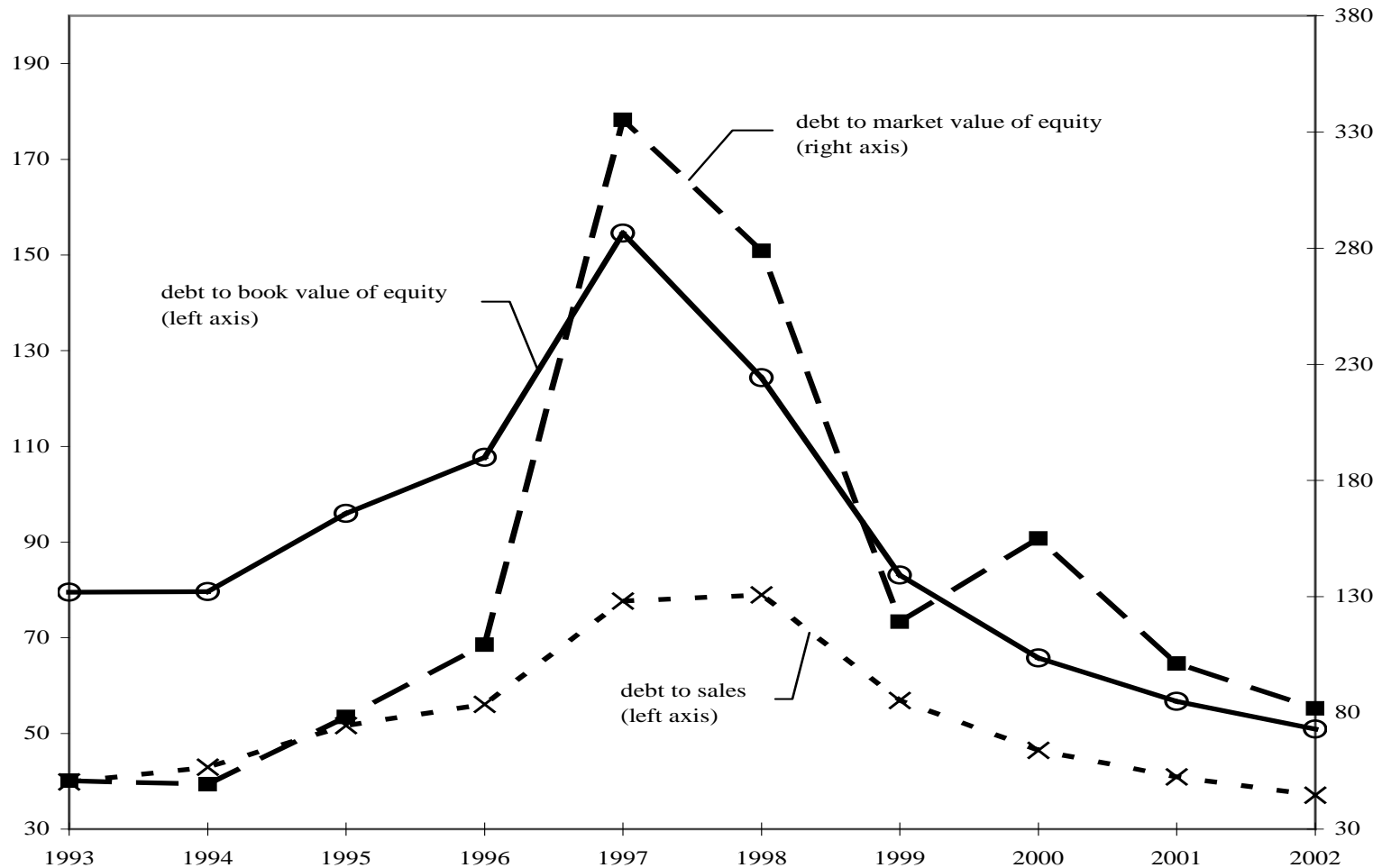
# Investment and Tobin's Q collapses

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



# Leverage ratios in East Asian Financial Crises

(listed corporations in Indonesia, Korea, Malaysia & Thailand)



Note: Cross-country arithmetic average of median leverage ratios across all publicly listed corporations in each country. Data from *Worldscope* database.

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# Credit Boom Events in Macro & Micro Data (Mendoza & Terrones 2009, 2012)

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# Methodology: Thresholds Method

- Country  $i$  is in a credit boom if:

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

$\phi$ : boom threshold factor

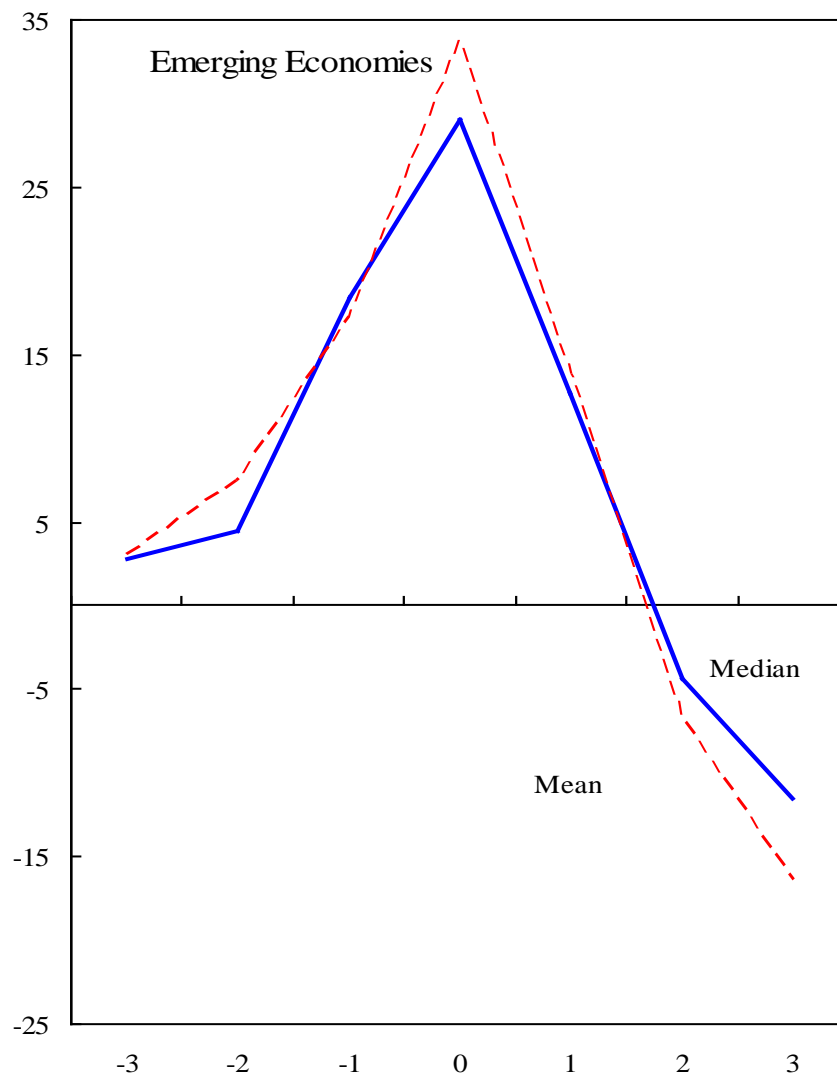
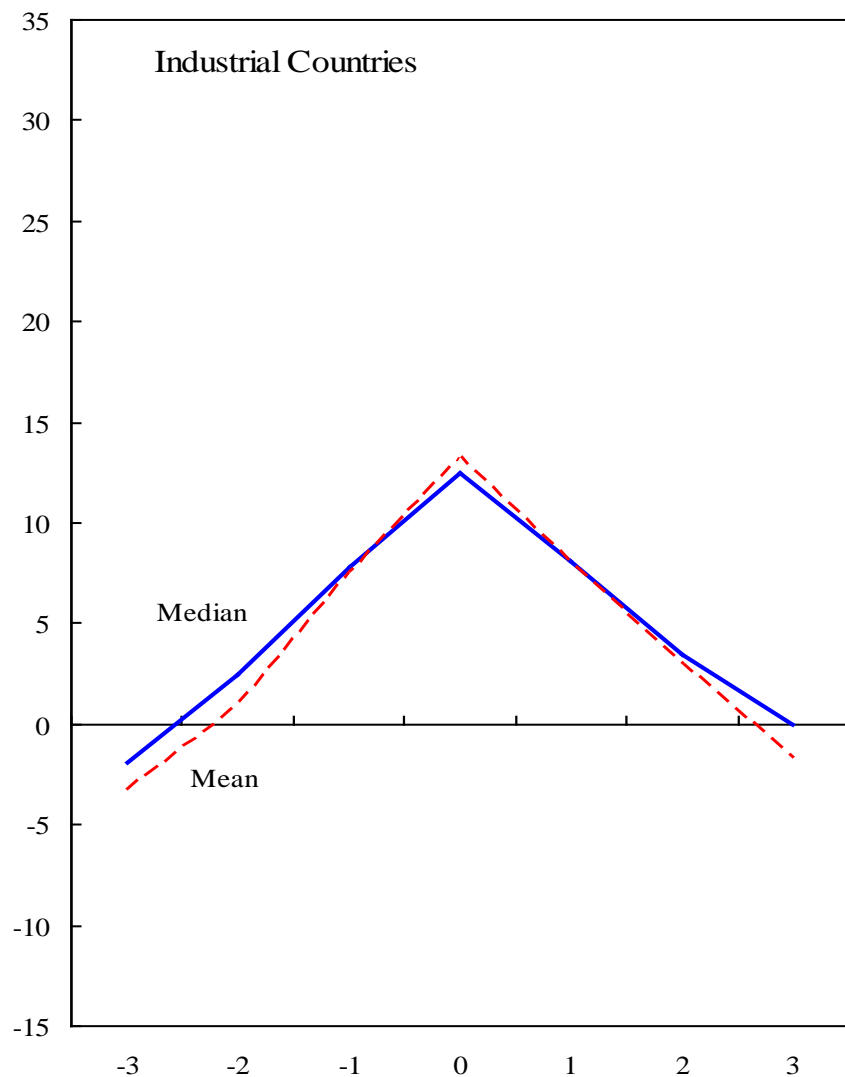
$l_{it}$ : deviation from HP trend in log real credit per capita

$\sigma(l_i)$ : standard deviation of  $l_{it}$ .

- Key differences with other methods (Gourinchas et al.01)
  1. Country-specific thresholds (  $\phi\sigma(l_i)$  )
  2. Credit measured as real credit per capita, not share of GDP
  3. Standard HP detrending, not “expanding trend”
- Credit booms observed with 2.8% frequency (70 episodes in 1960-2010 sample of 61 ICs and EMs), with strong macro/micro linkages

# Credit booms: seven year event windows

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

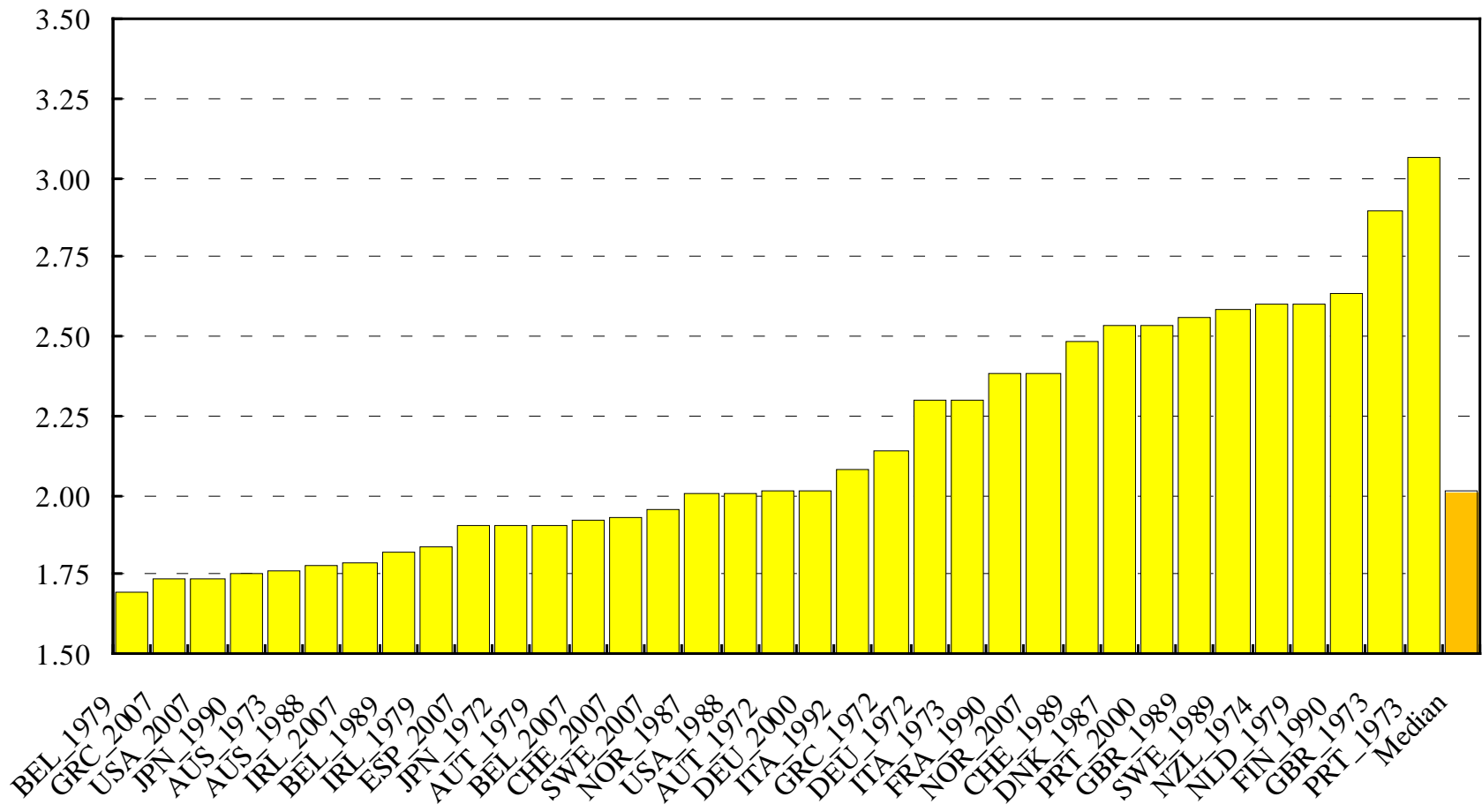




# Credit boom episodes

(relative to std. deviation of credit in each country)

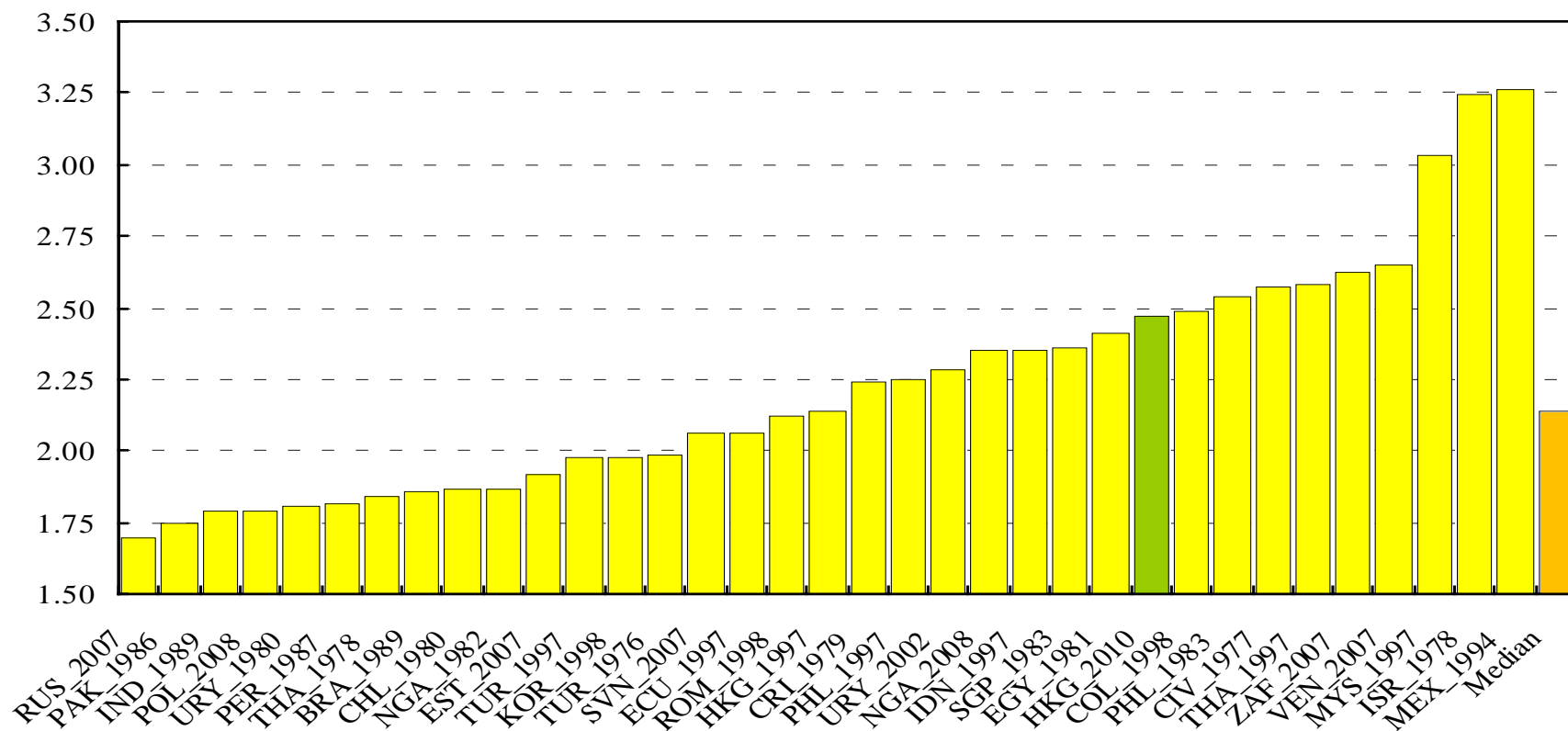
## INDUSTRIAL COUNTRIES



# Credit boom episodes

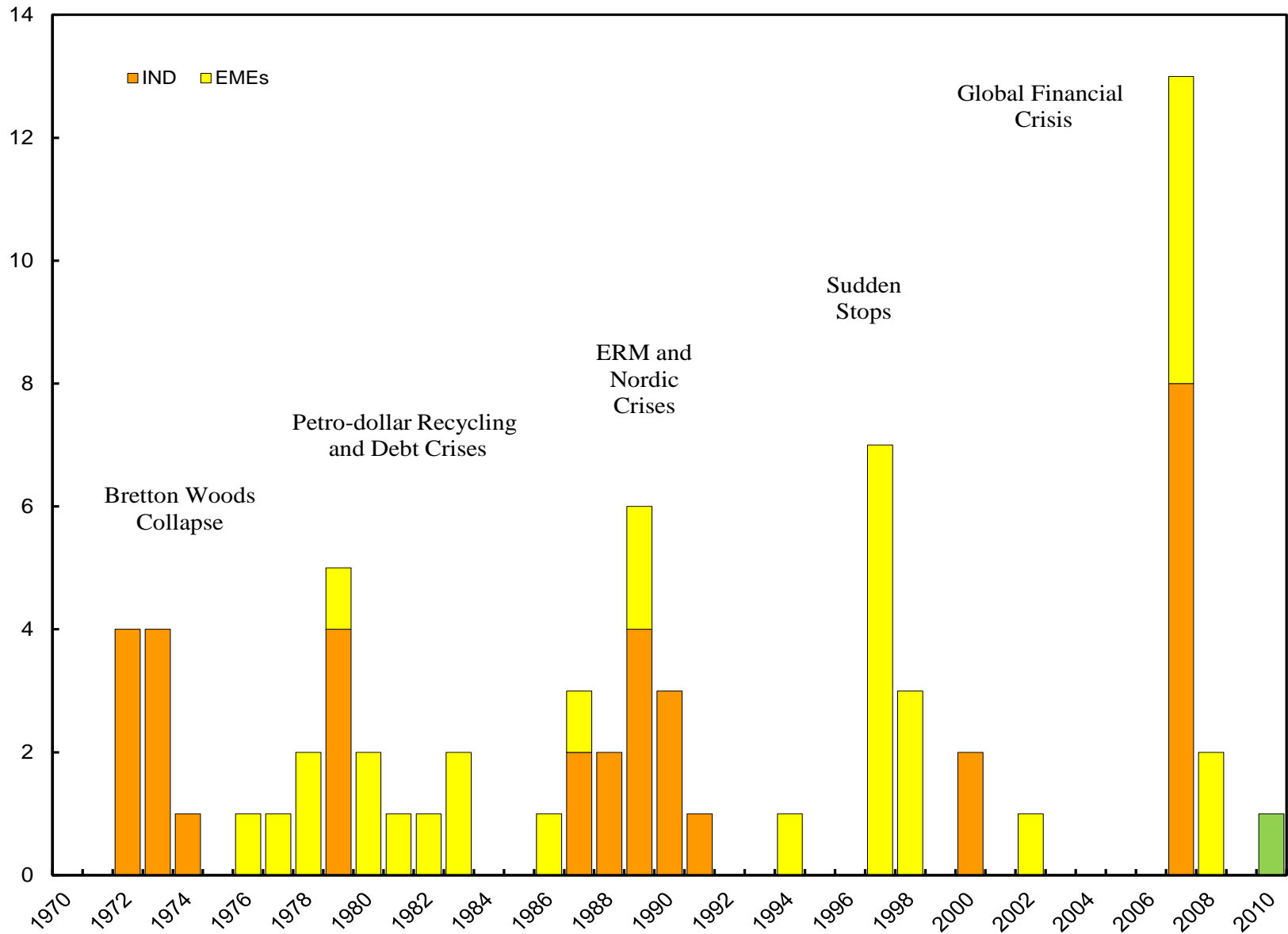
(relative to std. deviation of credit in each country)

## EMERGING MARKET ECONOMIES<sup>1/</sup>



<sup>1/</sup> Ongoing credit booms are shown in green.

# CBs are synchronized around “big events”



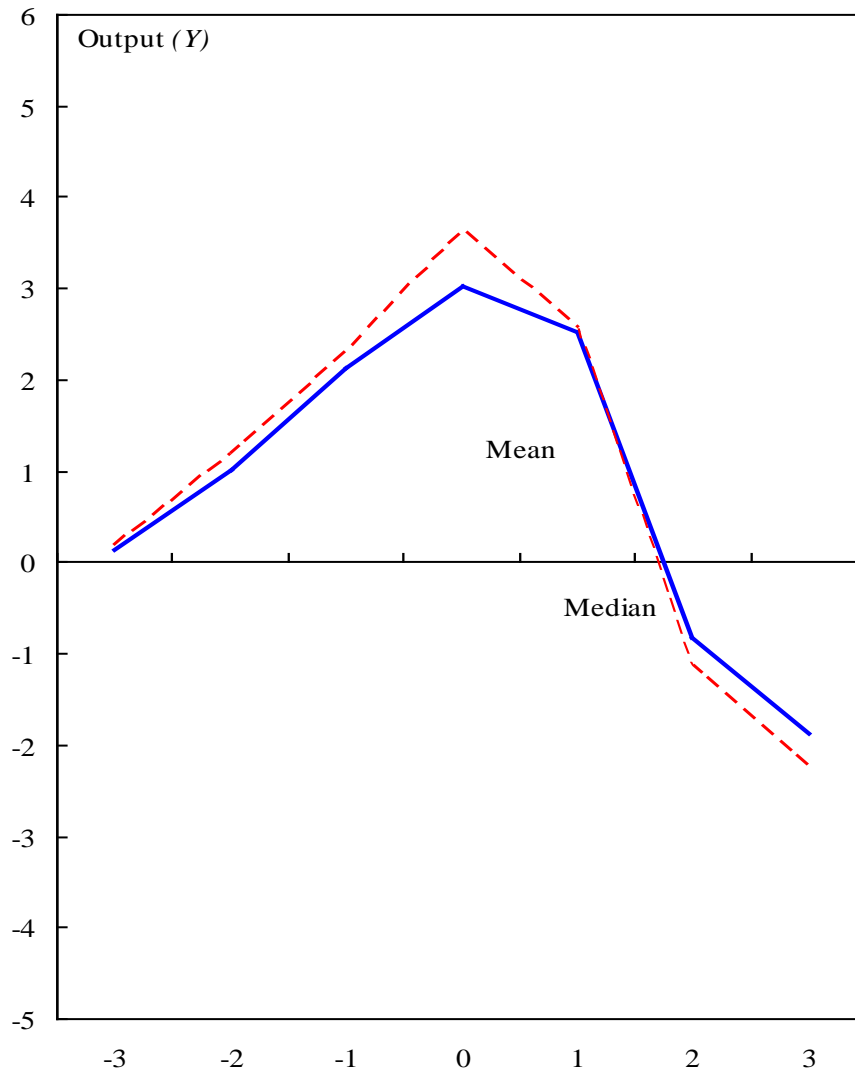
# Macro “credit cycles”

- Seven-year event windows centered at CB peaks
- Clear “credit cycle” pattern
  1.  **$y$ ,  $NTy$ ,  $c$ ,  $i$ , stock & housing prices, and  $REER$**  rise above trend in build up phase, drop below trend in the downswing
  2. **Current account** falls first and then rises.
  3. Minor changes in **inflation**
- Higher correlations with credit during CBs
- $\frac{1}{3}$ - $\frac{1}{2}$  of CBs are associated with *booms* in  **$y$ ,  $NTy$ ,  $c$ ,  $i$**
- Industrial countries show smaller fluctuations but normalized fluctuations are similar

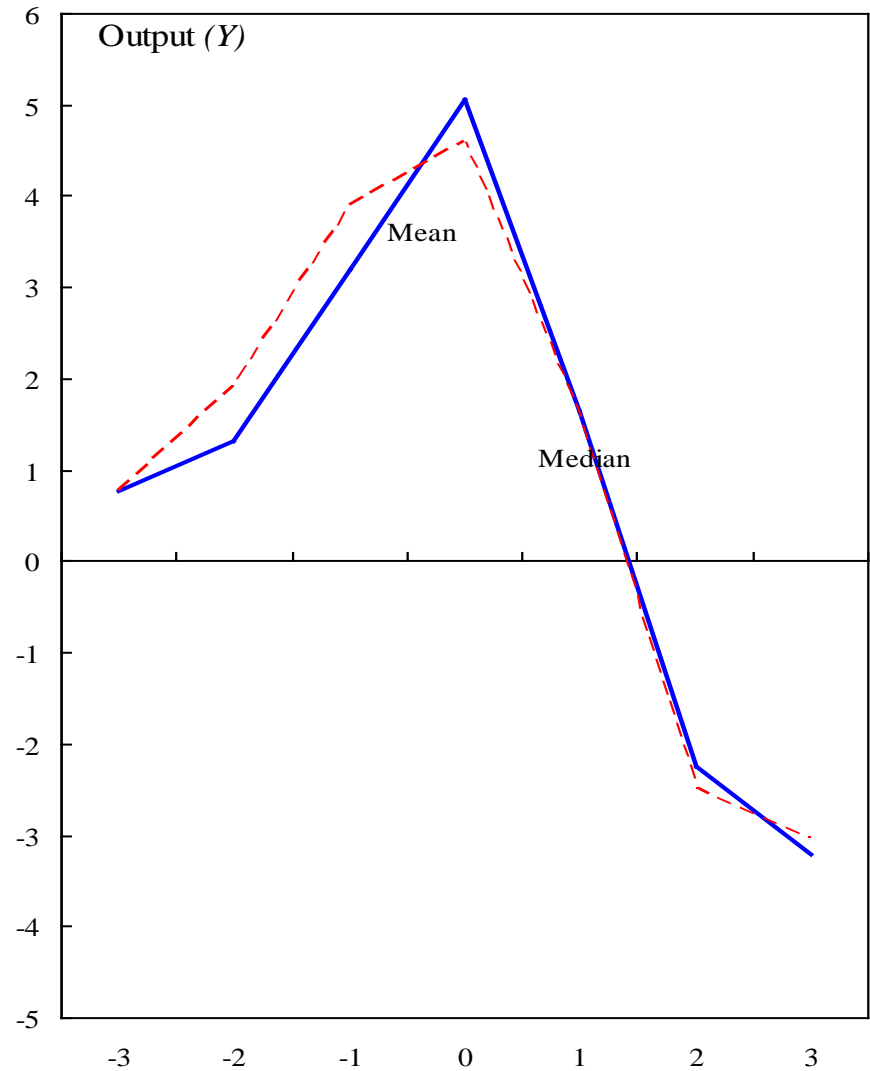
# Output credit cycles

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

Industrial Countries



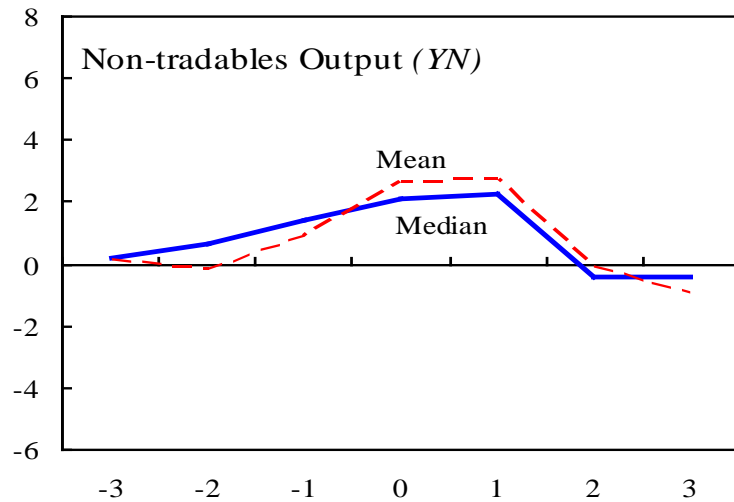
Emerging Economies



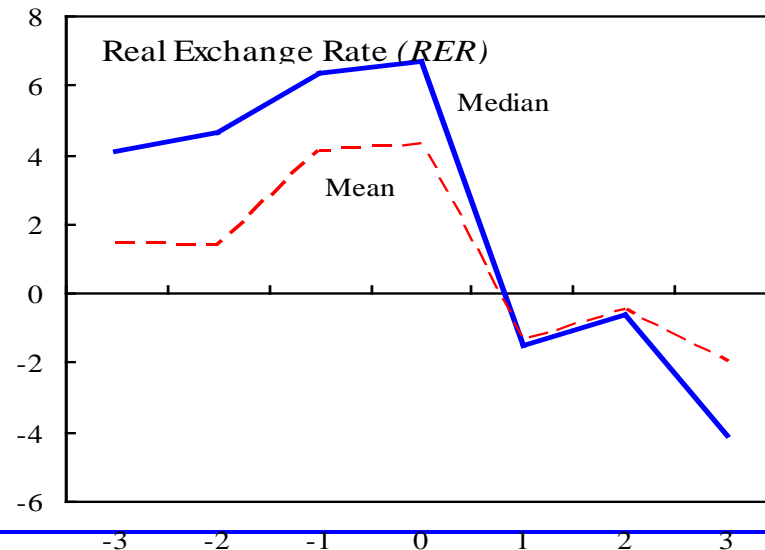
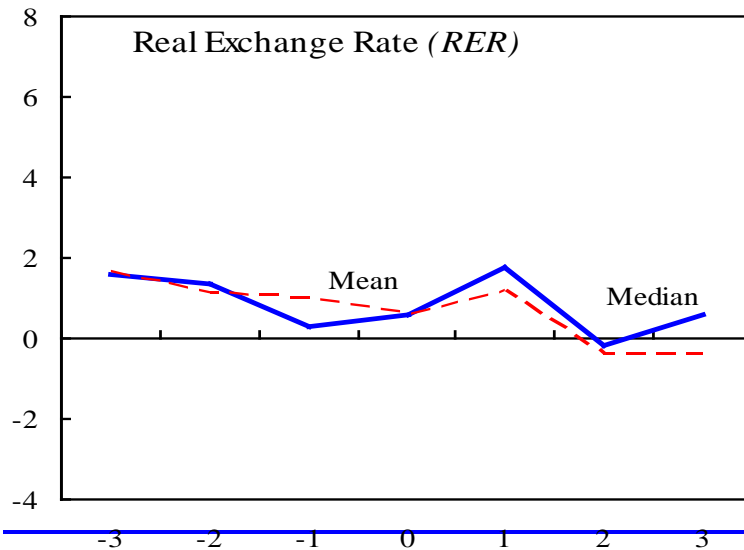
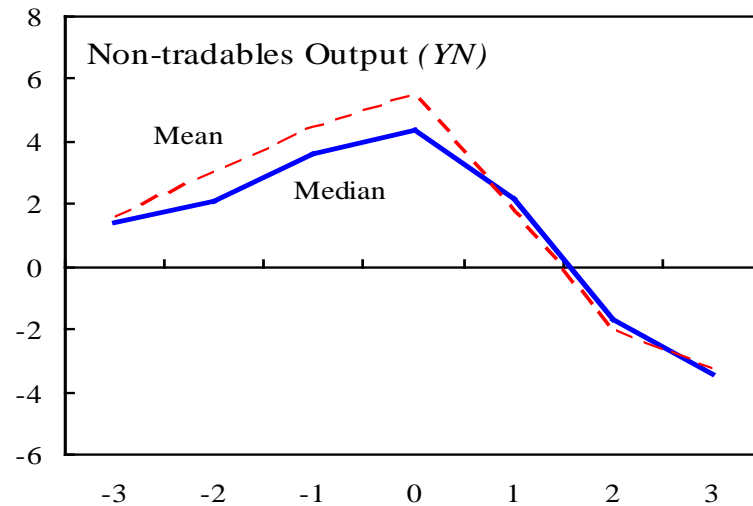
# Credit cycles in NT output & REER

(Cross-country means and medians of cyclical components)

Industrial Countries

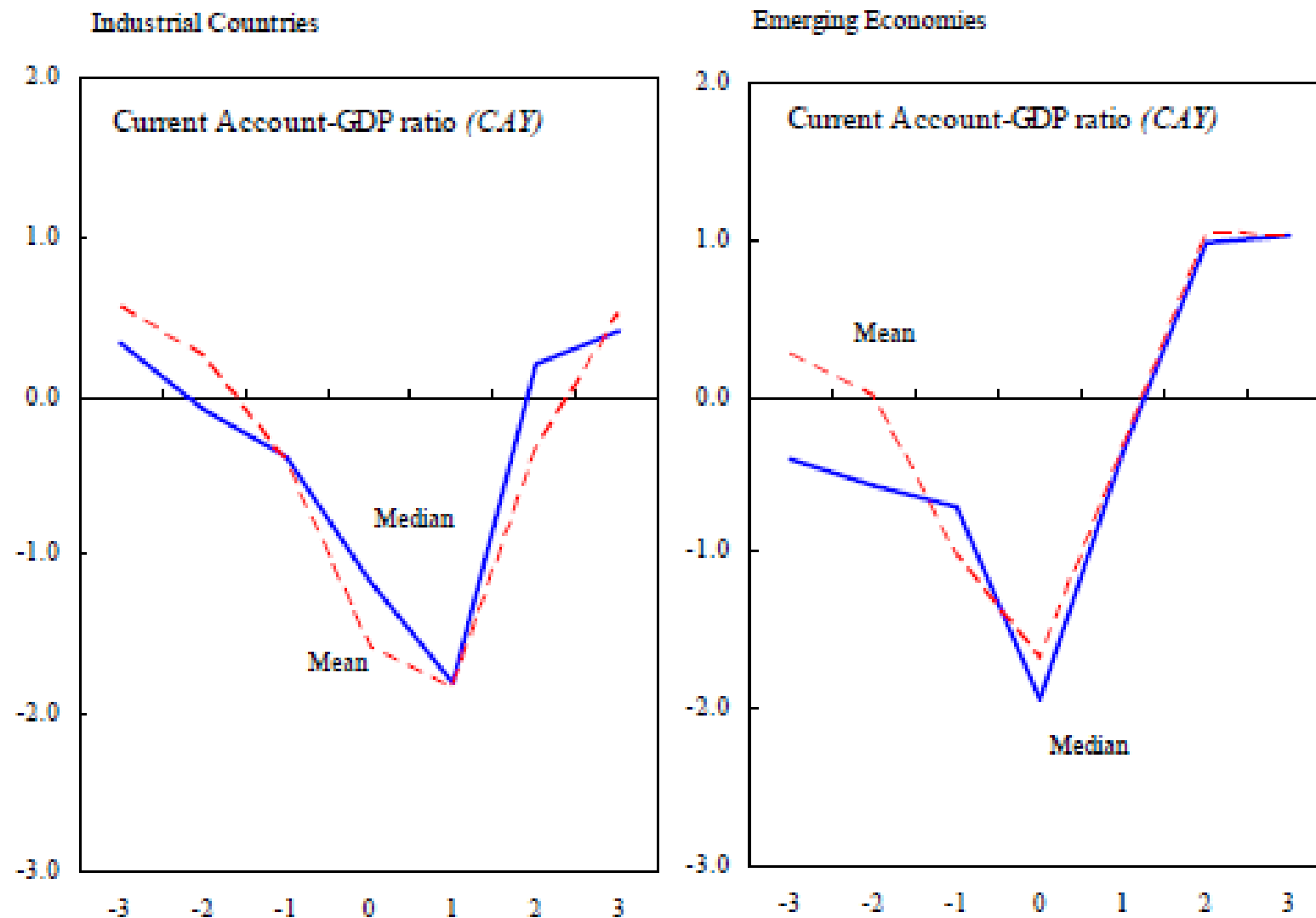


Emerging Economies



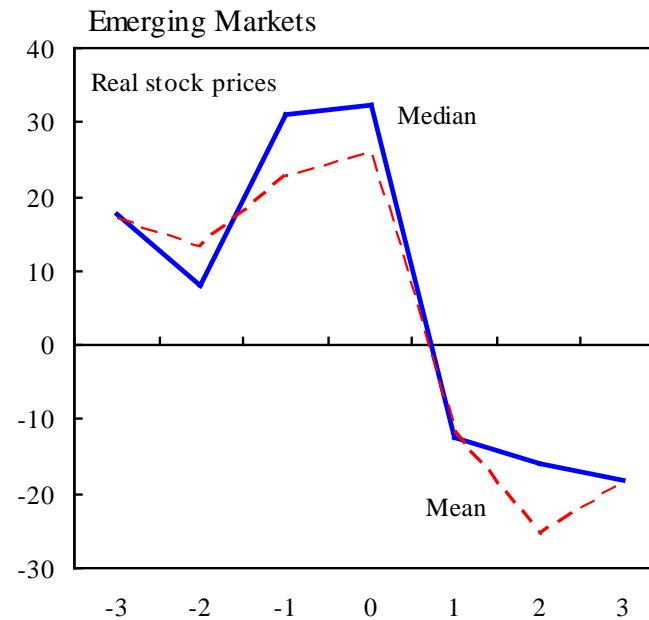
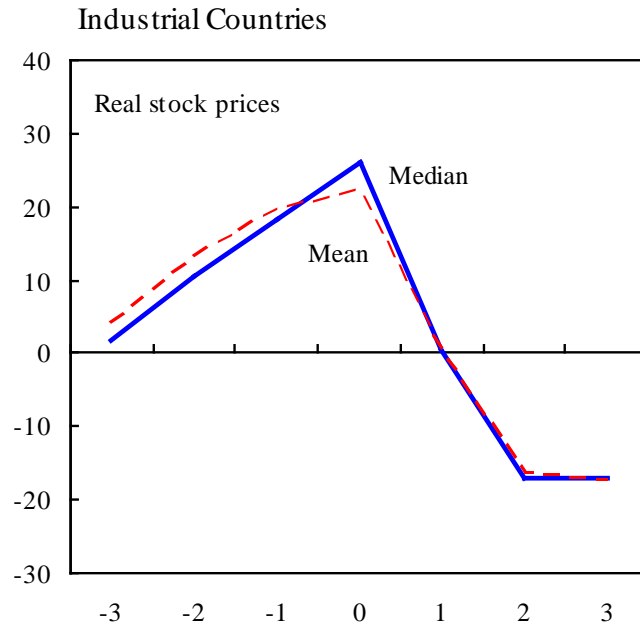
# Credit cycles in the current account

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



# Credit cycles in asset prices

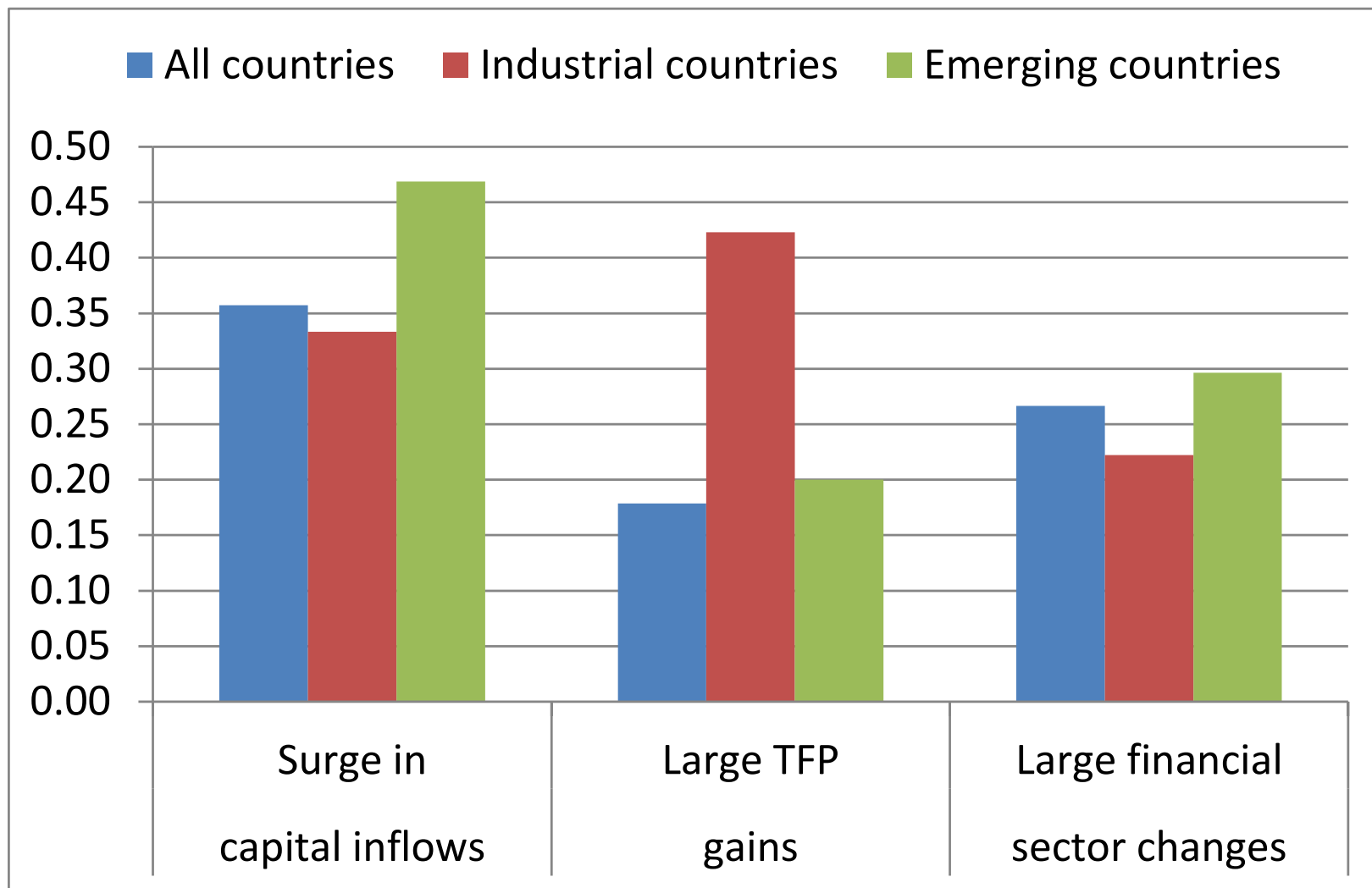
(Cross-country means and medians of cyclical component)





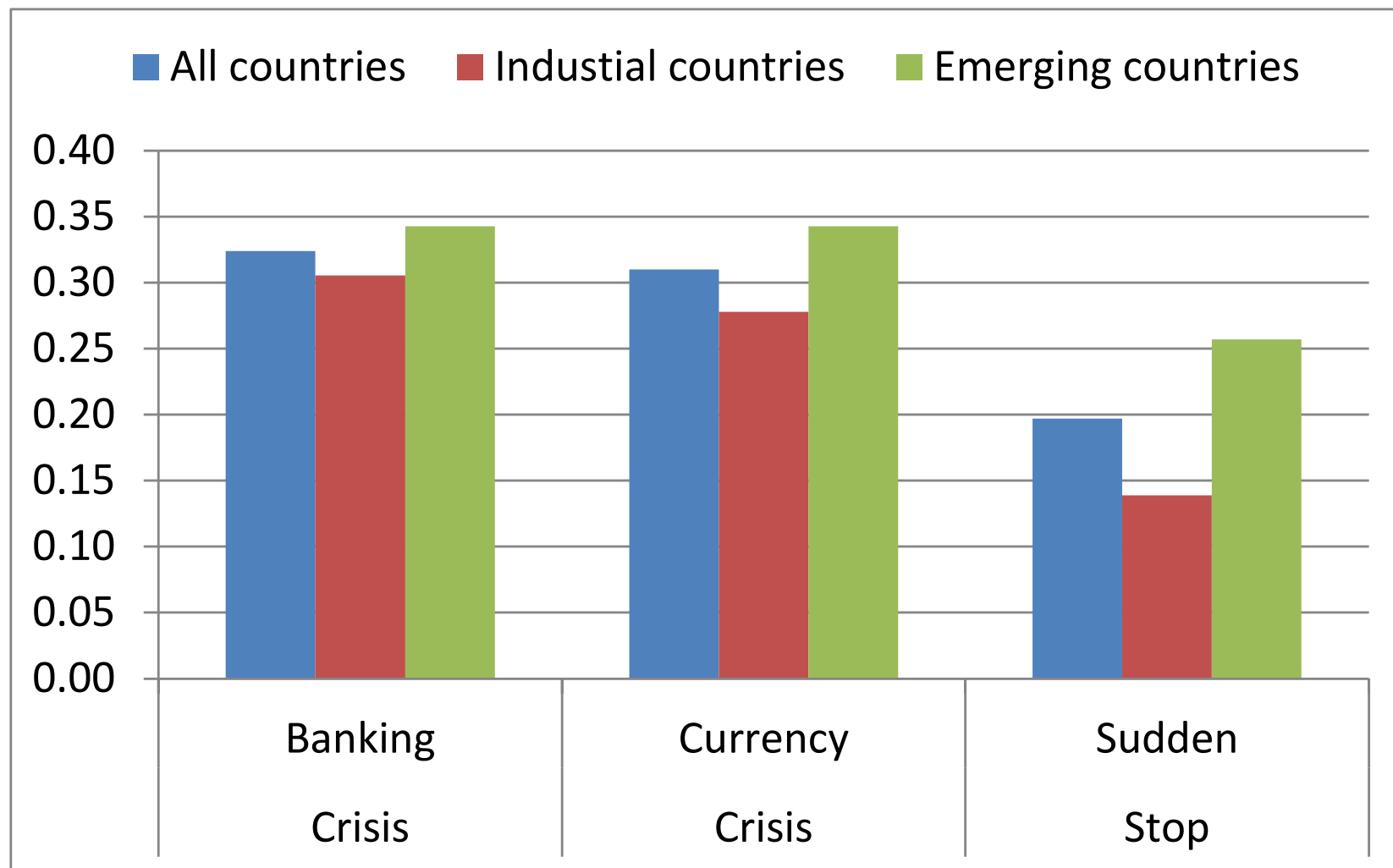
# Credit booms and potential triggers

(frequency analysis)

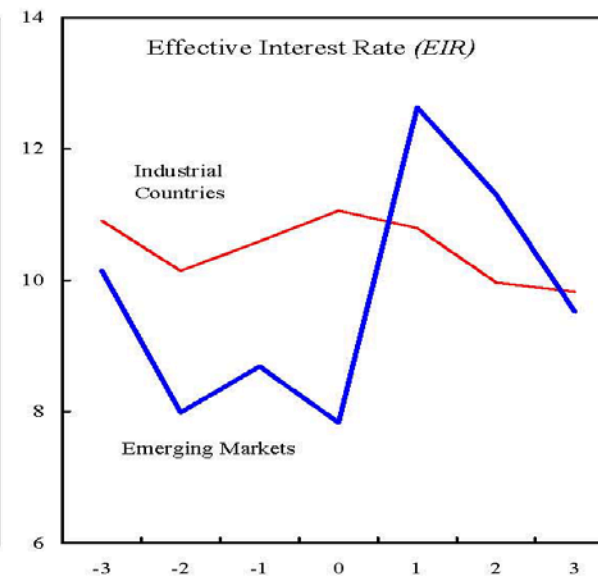
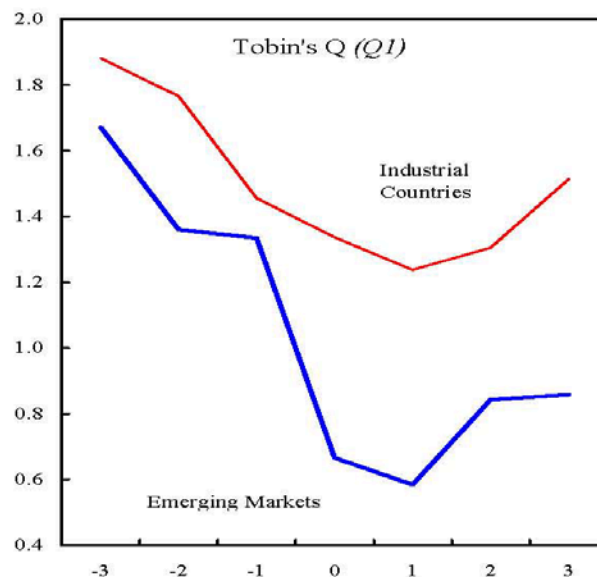
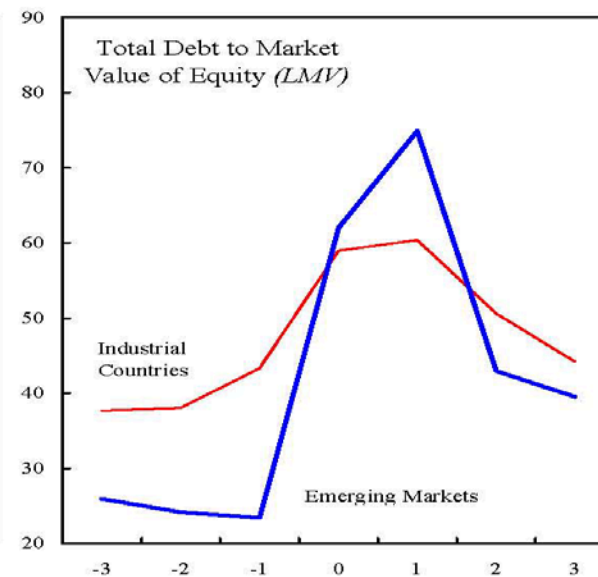
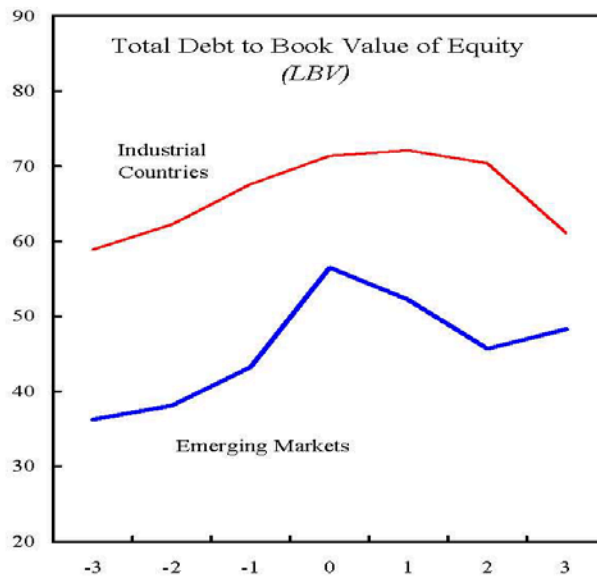


# Credit booms and financial crises

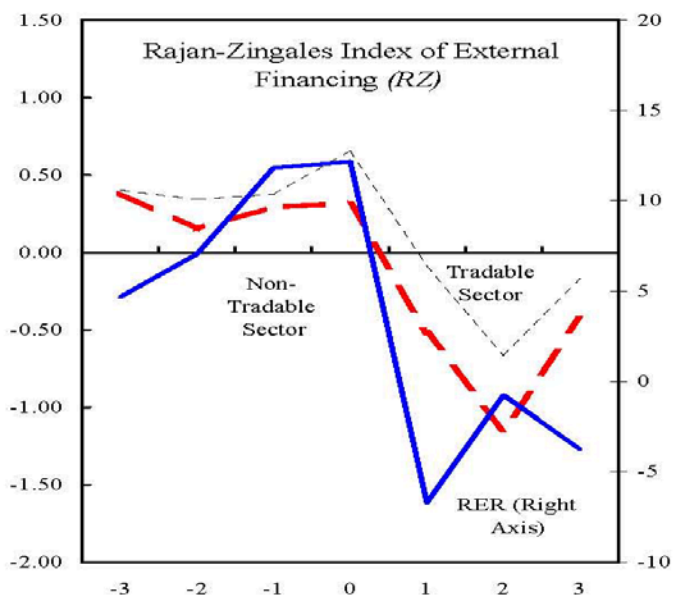
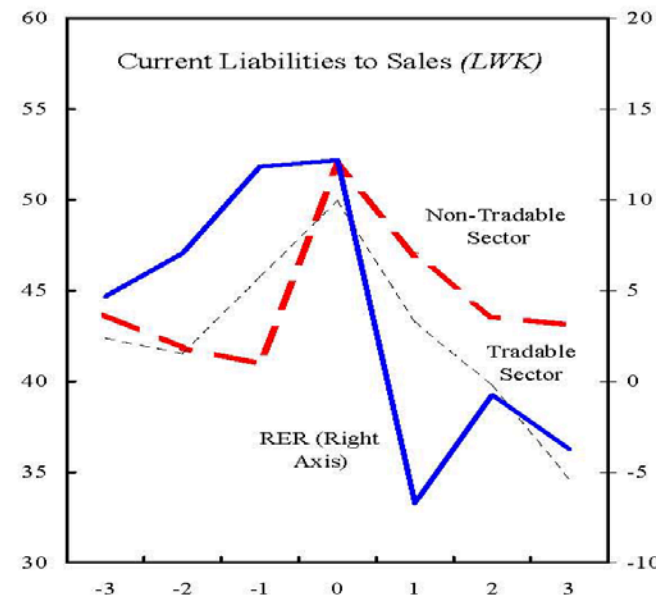
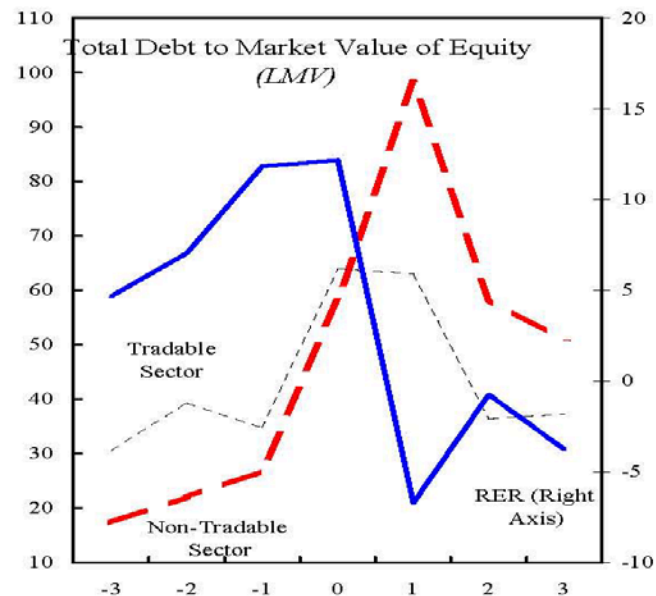
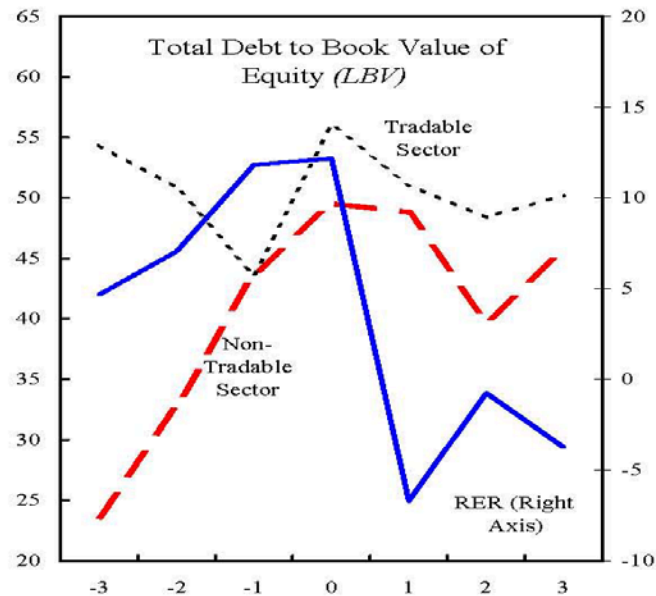
(frequency analysis)



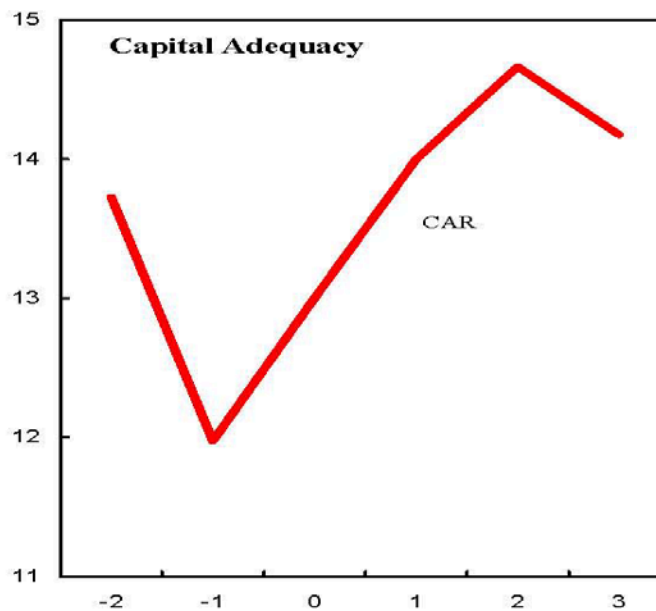
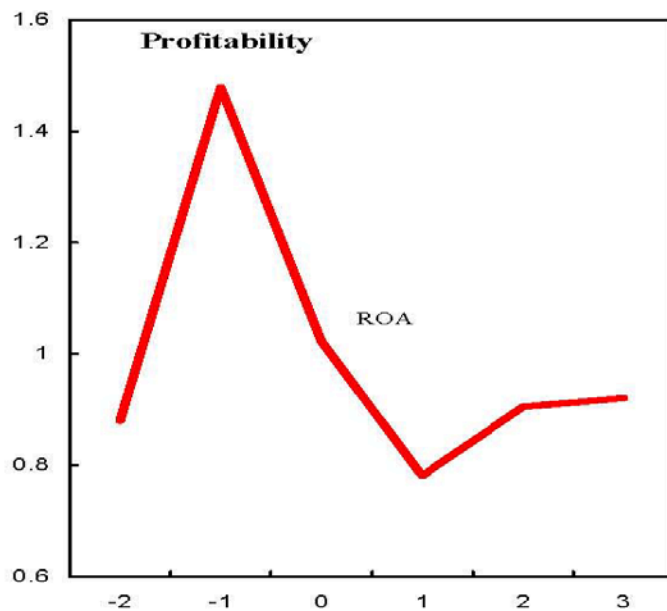
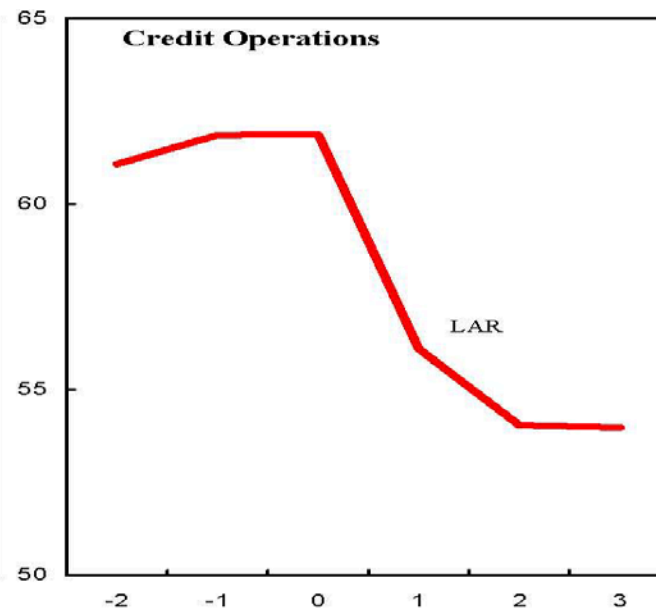
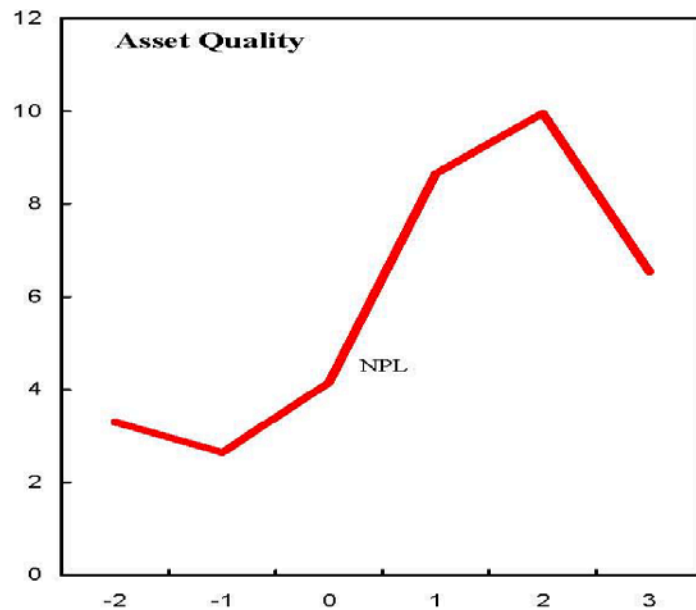
# Micro credit cycles (firm-level medians averaged across countries)



# EM corporations: Tradables v. Nontradables



# Bank-level indicators



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## **2. LIMITATIONS OF THE LITERATURE & LESSONS FROM FISHERIAN THEORY**

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# Limitations of the literature

1. Sudden Stops as exogenous surprises (large, unexpected shocks)
  - ❑ Calvo (98), Gertler et al. (07), Christiano et al. (04), Caballero & Krishnamurty (01), Cook & Devereux (06), ...
  - ❑ Agents do not take financial frictions, possibility of SSs into account
2. Financial frictions examined as perturbations to deterministic equilibria in which constraints always bind
  - ❑ Cannot generate crises nested within common cycles (amplification and asymmetry in response to standard shocks)
  - ❑ Abstracting from nonlinear effects caused by occasionally binding constraints (Fisher's debt deflation channel)
3. Quantitative relevance of credit frictions
  - ❑ Amplification effects may be too small (Kocherlakota (00))
  - ❑ Credit frictions could make output expand (Chari et al. (05))
  - ❑ Can credit frictions yield infrequent crises nested within normal cycles?

# Kocherlakota's critique

$$c_t + k_{t+1} + b_{t+1} = k_t^{\alpha_1} (1)^{0.4-\alpha_1} + Rb_t - e_t, \quad e_1 = \Delta, e_t = 0 \text{ for } t > 1$$

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

*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 ( $\alpha_1$ )	Amplification of Effect on	
	Land Price ( $Q_1 - Q_{ss}$ ) $\Delta^{-1} / Q_{ss}$	Output ( $Y_2 - Y_{ss}$ ) $\Delta^{-1} / Y_{ss}$
0.3	.008	.349
0.2	.006	.266
0.1	.004	.150



## Chari et al.'s (05) controversy

- *Exogenous credit constraints* (akin to sudden rise in gov. purchases) lead to output expansion because of wealth effect on labor supply
  - Correct result of a grossly counterfactual theory!
  
- *Endogenous credit constraints* lead to output expansion because mg. benefit of investment rises (extra capital relaxes constraints)
  - Incorrect result (assumes extra investment absorbs less resources than those gained by enhanced borrowing ability)
  
- But more recently (Chari, Ch & Kehoe (08) they seem to finally acknowledge financial crises happen: *“That the United States is undergoing a financial crisis cannot be disputed. Evidence of the financial crisis consists of the following: First, several major financial institutions have failed. Second, various stock markets have fallen,... Third, spreads...have widened dramatically.”*

# Lessons from Debt-Deflation (Fisherian) Theory

1. Crises are *endogenous* response to *typical* shocks when leverage ratios are high ( liabilities / value of collateral assets or income )
  - ❑ 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
  - ❑ Collateral constraint deflates Tobin's Q causing investment collapse
  - ❑ Reduced access to working capital causes immediate output drop
  - ❑ Relative price deflation lowers factor demands
3. Large amplification and asymmetry
  - ❑ Financial crises nested within regular cycles
  - ❑ Standard SOE-DSGE results if credit constraints do not bind
4. Consistent with stylized facts (except size of asset price drop)

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### **3. GENERAL FEATURES OF FISHERIAN MODELS**

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# Common elements of the models

- Small open economy DSGE framework:

1. Controls:  $y_t = [c_t, L_t, i_t, ca_t, tb_t \dots]$
2. Price vector:  $p_t = [p_t^N, q_t, w_t, R_t^q \dots]$
3. Endogenous states:  $x_{t+1} = [k_{t+1}, b_{t+1}]$
4. Exogenous states:  $e_t = [TFP, TOT, p_t^v, R, \tau, \dots]$

- *Incomplete* financial markets: non-state-contingent bonds

- Model-based stationary distribution of NFA (by using Uzawa-Epstein or Bewley-Aiyagari-Hugget preferences)

- *Imperfect* credit markets reflected in collateral constraints:

$$b_{t+1} \geq -\kappa_i g_i(y_t, p_t, x_t, e_t, k_{t+1}), \quad \kappa_i \geq 0$$

- Nonlinear feedback between  $b_{t+1}$  and  $p_t$  ( $y_t, x_t, k_{t+1}$ )
- Systemic credit externalities because of price effects on credit
- Wide class of credit constraints (Kiyotaki & Moore (97), Aiyagari & Gertler (99), Kocherlakota (00), liquidity constraints, etc.)

# Recursive competitive equilibrium

- Collateral constraints can affect households, firms, gov. in the decentralized equilibrium (each max. own payoff)
- If decentralized eq. can be represented as quasi-social planner's problem (negligible pecuniary credit externality), we can represent the equilibrium as

$$V(k, b, e) = \max_{k', b', c, n} u(c, L) + \exp(-v(c, L))E V(k', b', e')$$

$$\text{s.t.} \quad c = \varepsilon F(k, L, v) - p^v v - k' + k(1 - \delta) - \varphi(k, k') - b' + bR$$

$$b' \geq \kappa g(k', x, y, e, p)$$

- Alternatively, use methods to split individual from aggregate decisions & states, or solve with foc's, or use heterogeneous agents

# Endogenous financing premia

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

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

2. Higher excess asset returns, lower prices:

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

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

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

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

$$e_t^A f_v(\cdot) = p^v e_t^v [1 + \phi(r + \mu_t R)]$$

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## 4. AMPLIFICATION & ASYMMETRY IN FISHERIAN MODELS: A SIMPLE DETERMINISTIC EXAMPLE

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# Liability dollarization example

- Perfect-foresight, two-sector DGE model:

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

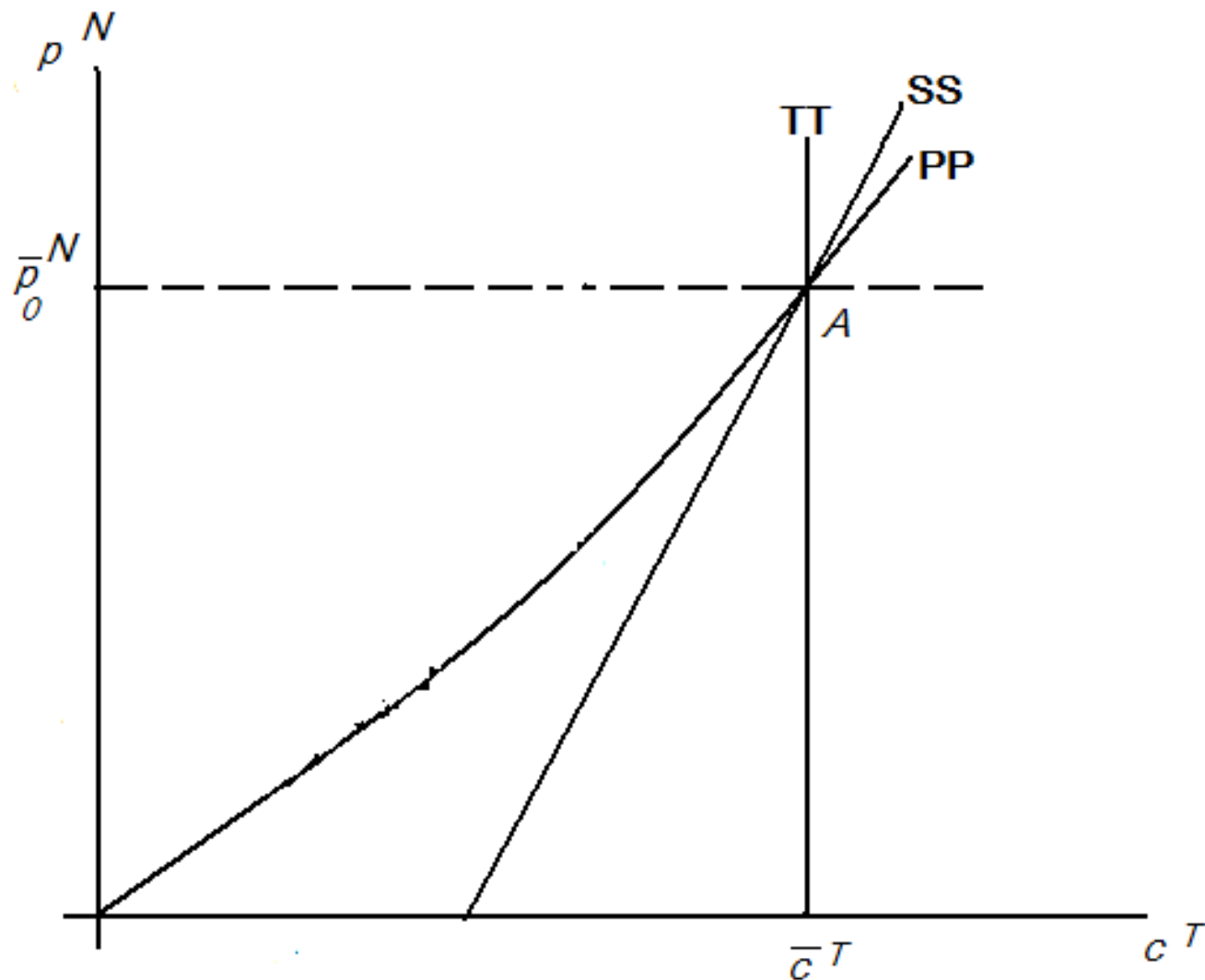
$$c_t^T + p_t^N c_t^N = y_t^T + p_t^N \bar{y}^N - b_{t+1} + b_t R$$

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

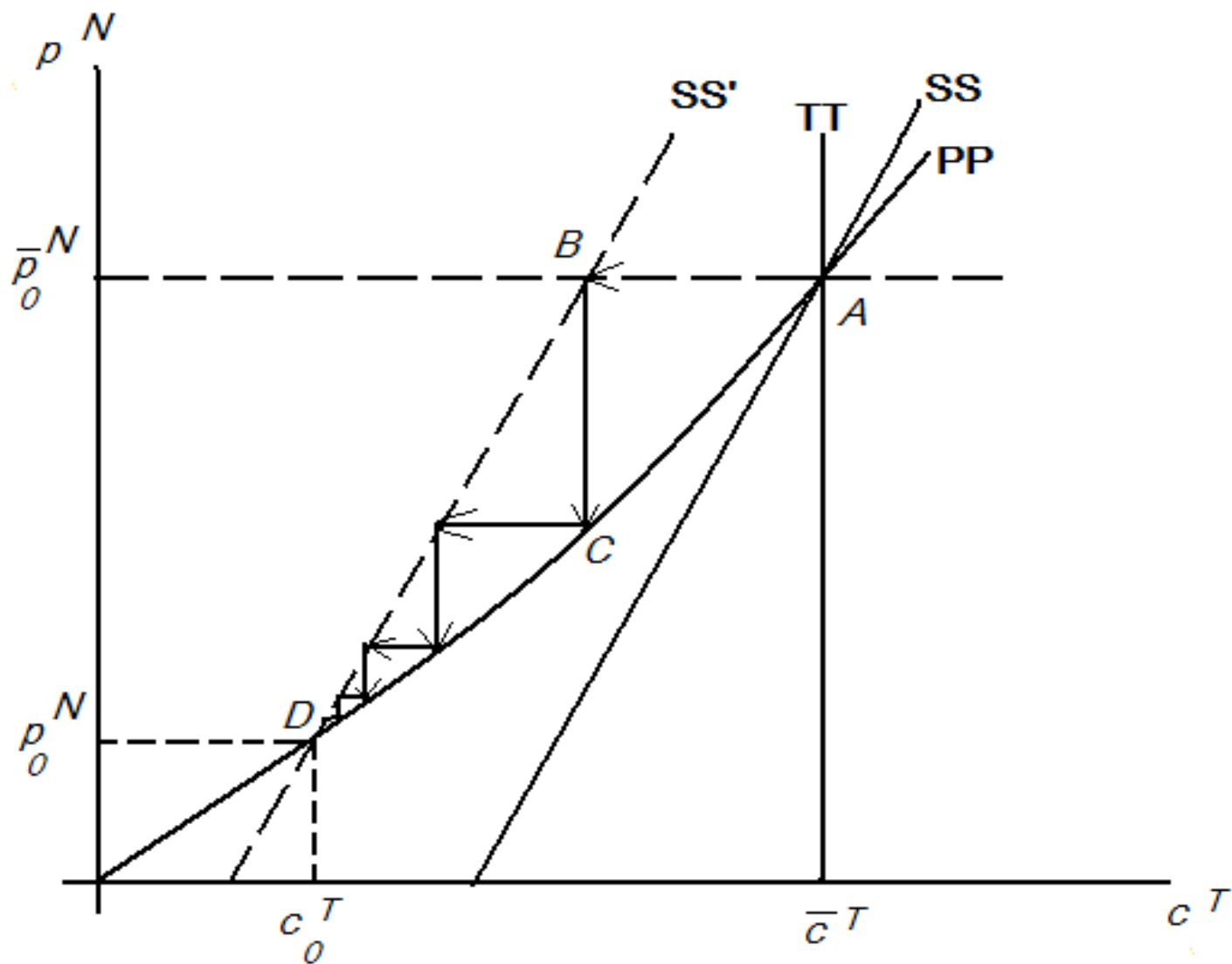
- With perfect credit markets, or if constraint does not bind: perfectly-smooth case of Permanent Income Theory
  - Wealth-neutral shocks to  $y_0^T$  do not alter equilibrium
- When the constraint binds: amplification & asymmetry in  $c$ ,  $p^n$ ,  $ca$ 
  - $ca$  reversal produced by DD channel, not by assumption and more than a one-shot balance sheet effect (as in Calvo (98))



# Equilibrium with nonbinding credit friction



# Amplification with the Debt-Deflation mechanism



# Calibration for quantitative application

- Functional forms:

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

- Parameter values:

- $\beta = 0.96, \quad \sigma = 2$

- Mendoza's (02) estimates for Mexico:

$$a = 0.342, \quad y^T / (p^N y^N) = 1.543, \quad c^T / y^T = 0.66, \quad c^N / y^N = 0.71$$

- $\mu = 0.204, \quad 1/(1+\mu) = 0.83$  upper bound of estimates for LA

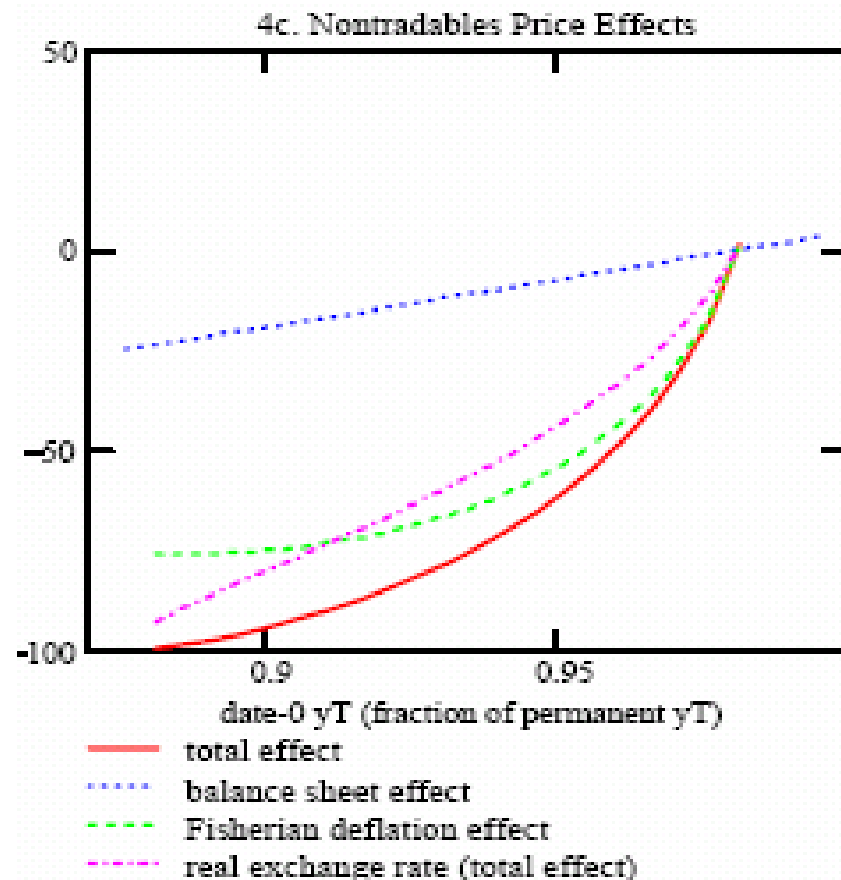
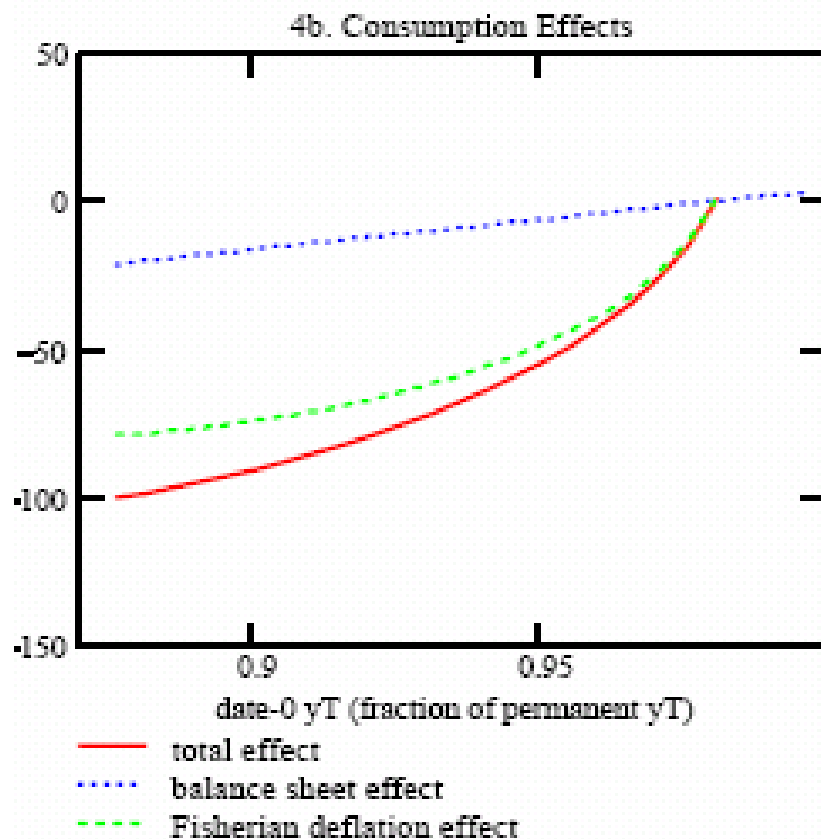
- Initial foreign debt set at 1/3 of GDP

- Credit limit set at  $\kappa = 1/3$

- Permanent output normalized to 1

# Crisis effects of the Debt-Deflation mechanism

- 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.



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# Limitations of this experiment

- It only tells us that very bad things can happen if you were borrowing a lot and suddenly, unexpectedly credit stops
  - It doesn't tell us:
    - How knowing this may happen affects borrowers' behavior before the credit crunch?
    - What magnitudes of shocks can trigger the credit constraint?
    - 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 the potential for large amplification and asymmetry in macro responses to shocks!
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## 5. QUANTITATIVE DSGE MODELS

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# Model 1: Assessment of the New Mercantilism

(Durdu, Mendoza & Terrones, “*Precautionary Demand for Foreign Assets in Sudden Stop Economies*,” *JDE*)

- Is the 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 liability dollarization and imported intermediate goods
  - Quantifying amount of optimal 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 specification of preferences

# 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
<i>Median</i>		7.66
<i>Median Asian Countries</i>		13.17



# DSGE model

- Preferences

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

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

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

- Households' budget constraint

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

- Credit constraint w. liability dollarization

$$b_{t+1} \geq -\kappa \left[ \varepsilon_t^T y^T + \pi_t^N \right] \geq \Omega, \quad \text{where} \quad \pi_t^N \stackrel{eq}{=} p_t^n y_t^n - p^m m_t$$

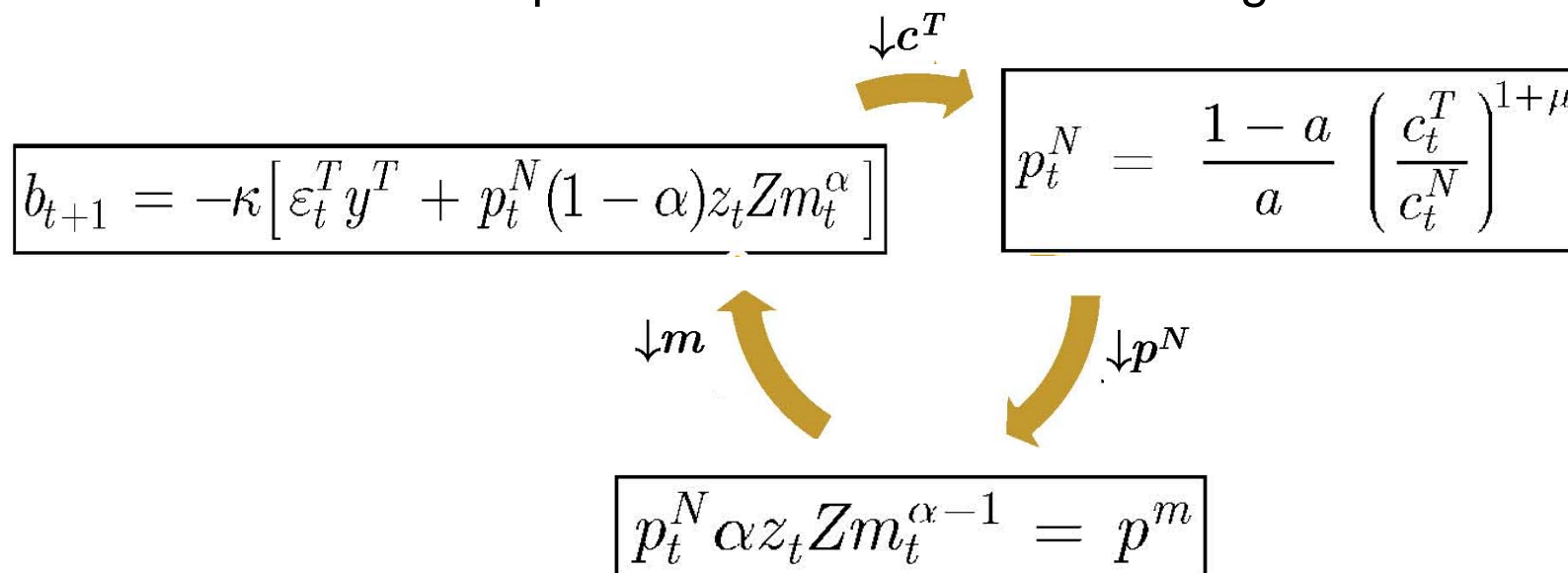
- Nontradables produced with imported inputs

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

- Shocks to tradables endowment and nontradables TFP

# Endogenous Financial Crises

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



- Extra incentive for precautionary savings
  - “Excessive” crises ruled out from stochastic steady state
  - Long-run probabilities of crises: 3.9% (BAH), 7.9% (UE)

# Why two preferences?

- Subjective discounting affects self insurance incentives

- CRRA utility imposes Aiyagari's *Natural Debt Limit*

- Since  $u'(\cdot) \rightarrow \infty$  as  $c \rightarrow 0$ ,

$$b_{t+1} \geq \phi \geq -\min(\varepsilon_t y + A) / r$$

- BAH setup:

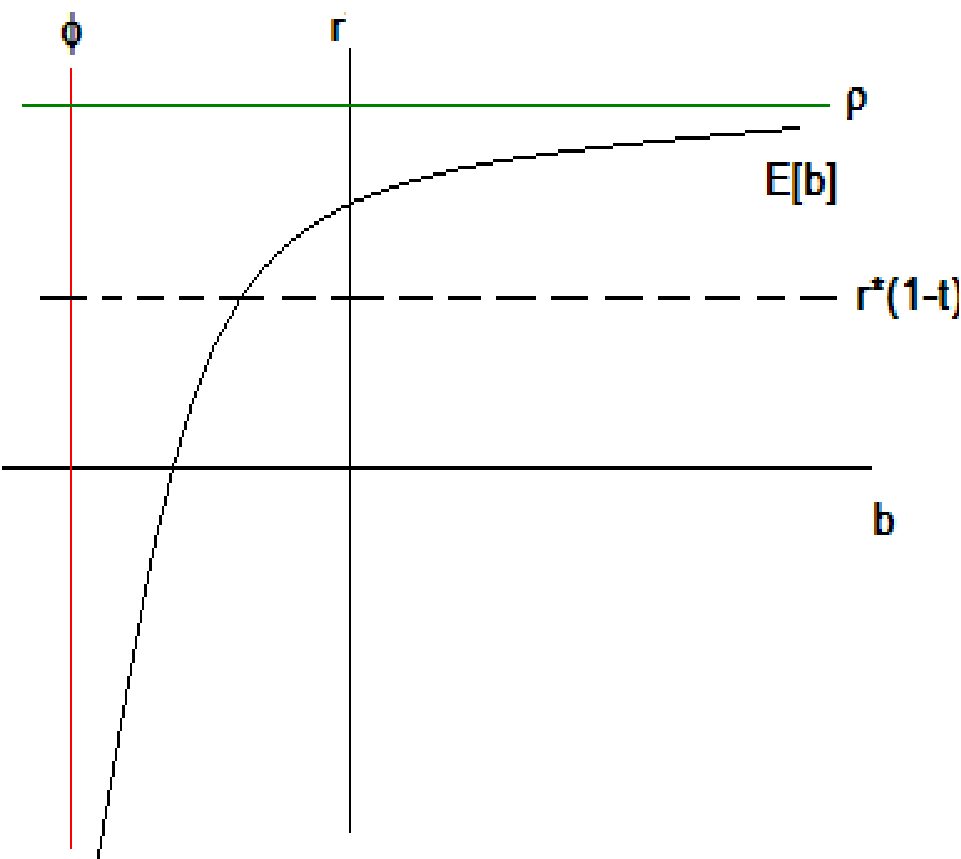
- Equilibrium requires  $\rho^{\text{BAH}} > r$  otherwise  $b \rightarrow \infty$
  - $E[b]$  is inelastic at  $\phi$  for low  $r$ , and infinitely elastic as  $r \rightarrow \rho^{\text{BAH}}$
  - Skewed wealth distributions

- UE setup:

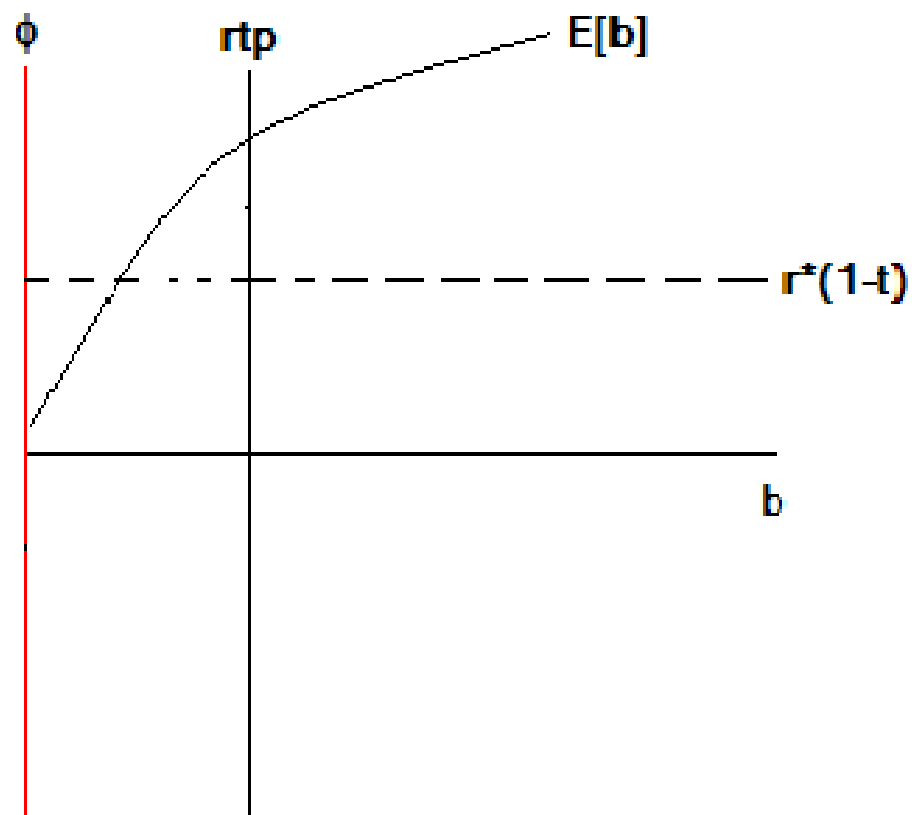
- RTP rises w. past consumption
  - Well-defined equilibrium requires  $\rho^{\text{UE}} \leq \gamma$
  - Symmetric wealth distributions

# Elasticity of savings under BAH & UE preferences

Mean foreign assets: BAH preferences



Mean foreign assets: UE preferences



# Recursive problem

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

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

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

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

# Calibration

$\rho^{BAH}$	Rate of time preference in the BAH setup	0.059
$\rho^{UE}$	Rate of time preference elasticity in the UE setup	0.187
$\gamma$	Coefficient of relative risk aversion	2.000
$\mu$	Elasticity of substitution	0.316
$a$	CES weight of tradable consumption	0.341
$\phi$	Ad-hoc debt limit	-0.700
$\alpha$	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:

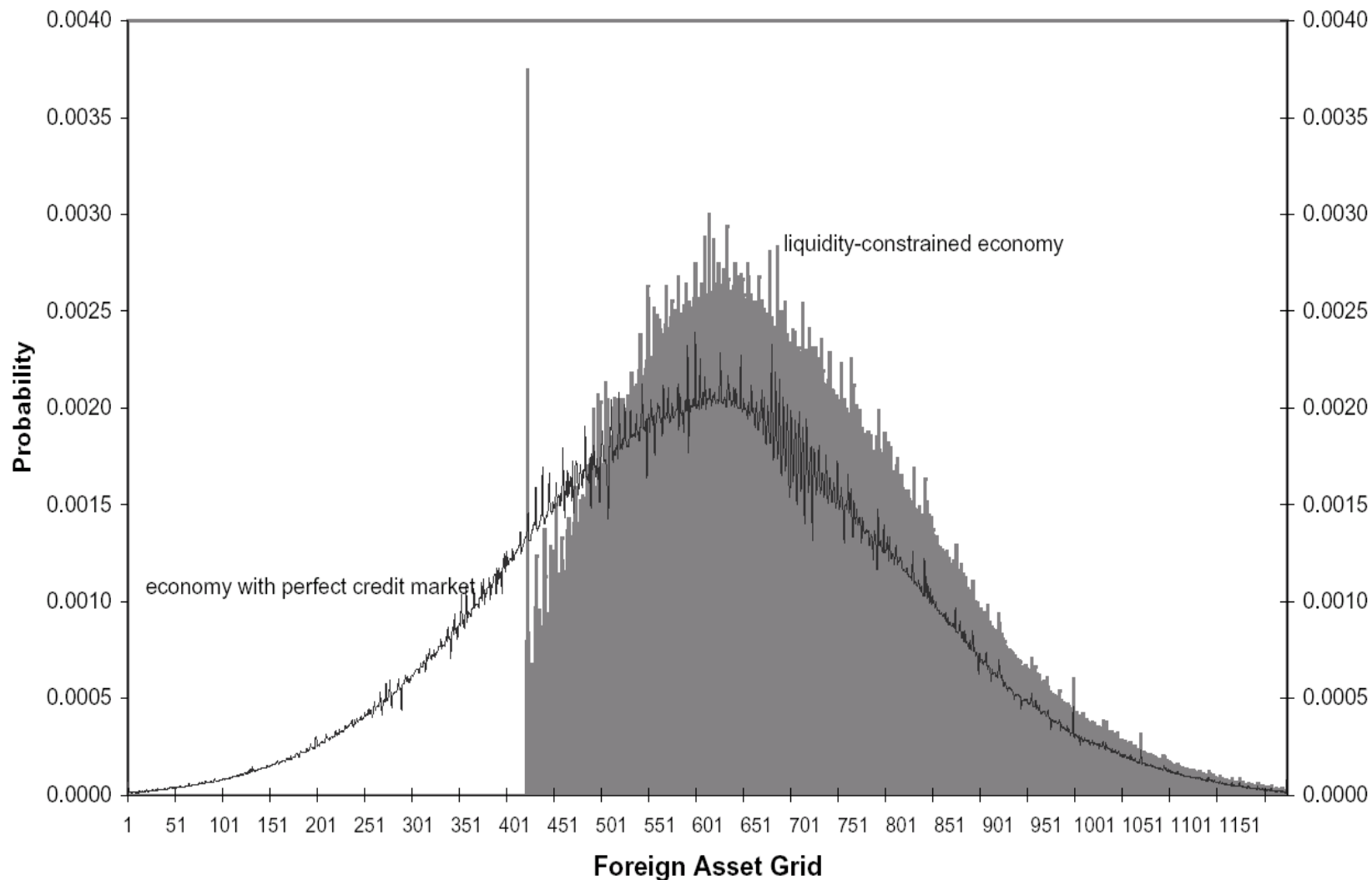
$$\hat{\sigma}_{y^T} = 0.0334, \quad \hat{\sigma}_{y^N} = 0.0305, \quad \hat{\rho}_{y^T} = 0.587, \quad \hat{\rho}_{y^N} = 0.483, \quad \text{and} \quad \hat{\rho}_{y^T, y^N} = 0.516$$

- 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 net foreign assets

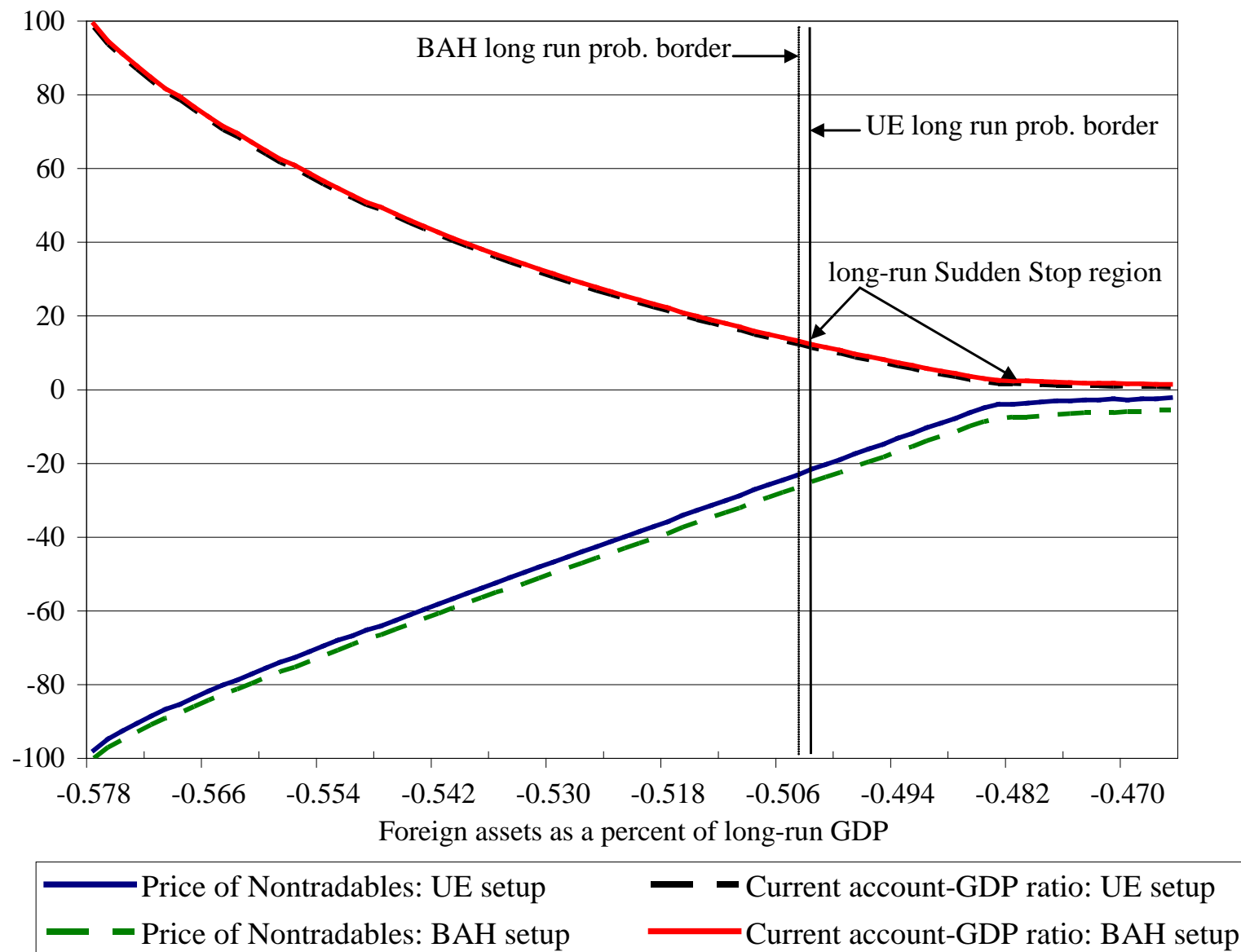


# Stochastic steady states

	UE		BAH	
	Econ w/ perfect credit markets	Econ w/ binding credit constraints	Econ w/ perfect credit markets	Econ w/ binding credit constraints
<b>Foreign assets/output ratio</b>				
Mean	-0.424	-0.378	-0.447	-0.243
Coefficient of variation	8.689	6.342	19.405	18.179
Correlation with GDP	0.365	0.277	0.495	0.441
First Order Autocorrelation	0.985	0.974	0.995	0.994
<b>Coefficients of variation (in percent)</b>				
Consumption of tradables	1.643	1.523	3.139	2.993
Consumption of nontradables	5.369	5.379	4.926	4.896
Consumption	3.626	3.634	3.169	3.109
Price of nontradables	6.622	6.550	8.099	8.053
Current Account-GDP ratio	1.453	1.416	1.950	1.939
Tradables GDP	3.345	3.345	3.345	3.345
GDP in units of tradables	2.213	2.184	3.292	3.271
Nontradables GDP	3.050	3.059	2.797	2.793
Intermediate input	3.805	3.688	5.846	5.754
<b>Correlation with GDP in units of tradables</b>				
Consumption of tradables	0.374	0.341	0.804	0.803
Price of nontradables	0.749	0.740	0.867	0.873
Current Account-GDP ratio	-0.141	-0.142	-0.474	-0.497
Nontradables GDP	-0.579	-0.579	-0.562	-0.591

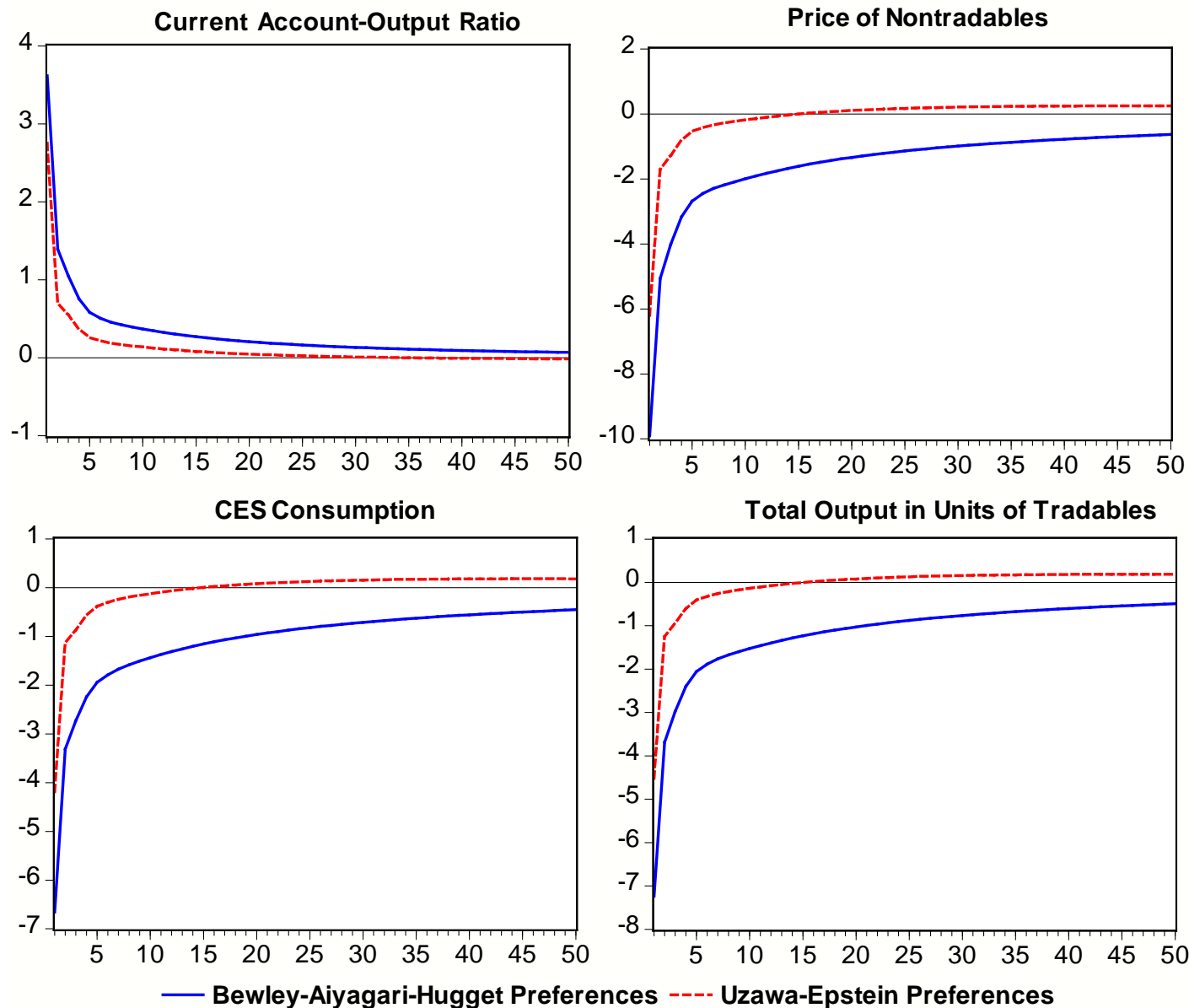
# Impact amplification effects in financial crises region

(excess responses to 1 s.d. shocks)



# Crisis dynamics at a 49% debt ratio

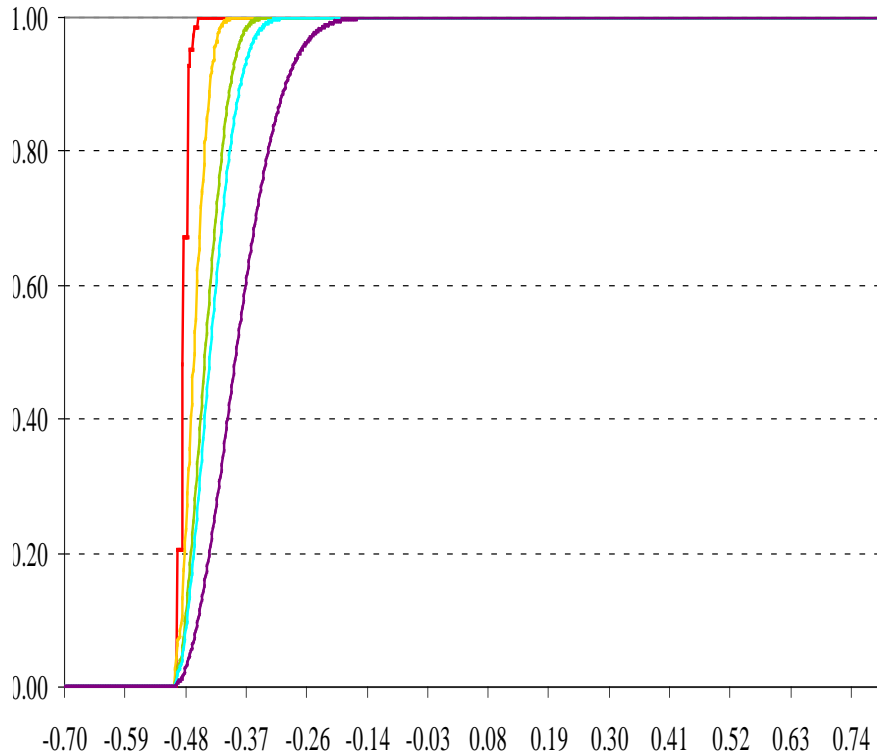
(excess responses to 1 s.d. shocks)



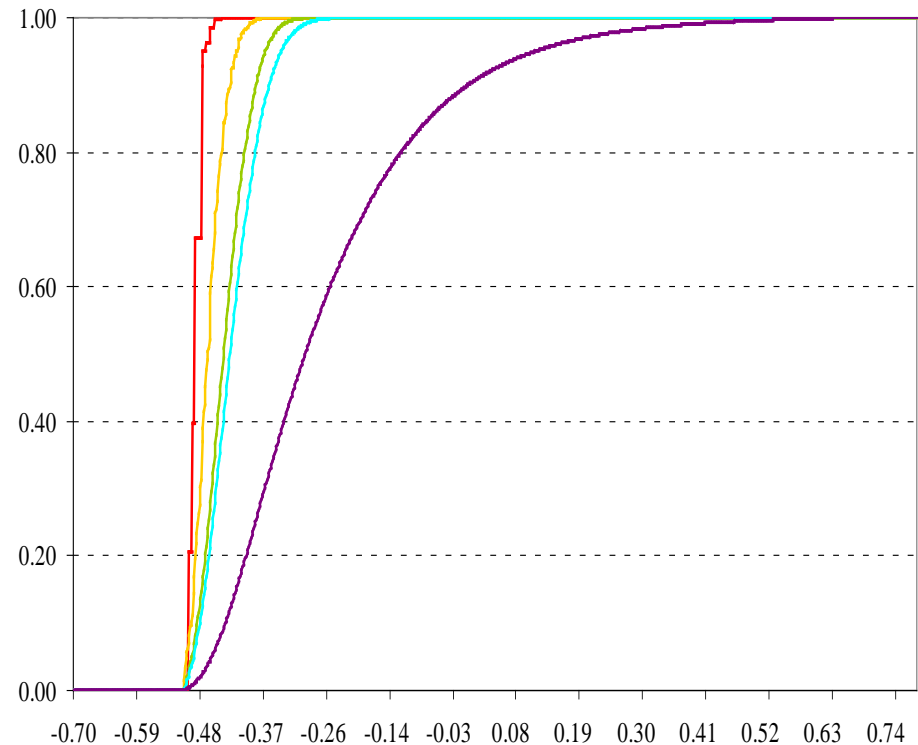
# Transitional distributions in ciris economies

(foreign assets in percent of mean GDP)

UE setup



BAH setup



— 2 years — 5 years — 10 years — 15 years — Long-run distribution

# 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%

## Model 2: Global asset trading (*Mendoza & Smith, JIE 2006*)

### ■ Two-agent equilibrium asset pricing model

- Margin constraint:  $b_{t+1} \geq -\kappa q_t \alpha_{t+1} k$
- Endogenous supply-side but independent of financial frictions
  - GHH utility  $u(c-G(L))$ :  $MRS(c,L)$  independent of  $c$
  - Competitive firms, no capital accumulation:  $e_t^A F(L_t, K)$
- Foreign securities firms with trading costs:  $q_t \left( \frac{a}{2} \right) (\alpha_{t+1}^* - \alpha_t^* + \theta)^2$
- Foreign traders' demand:  $\alpha_{t+1}^* - \alpha_t^* = 1/a \left[ q_t^f / q_t - 1 \right] - \theta$

### ■ SS are endogenous response to 1sd. *TFP* shocks:

- Requires high enough leverage  $(-b_t / q_t \alpha_t k)$ , 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 budget constraint (need also short selling constraint on equity):

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

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

- 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

Figure 1a. Ergodic Distributions of Domestic Equity Holdings

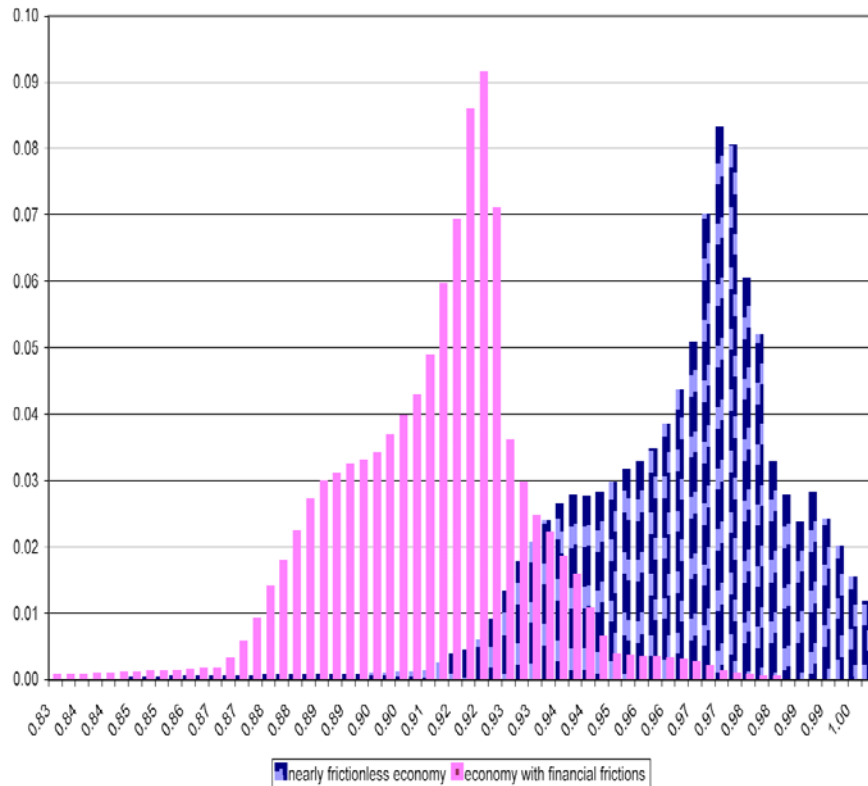
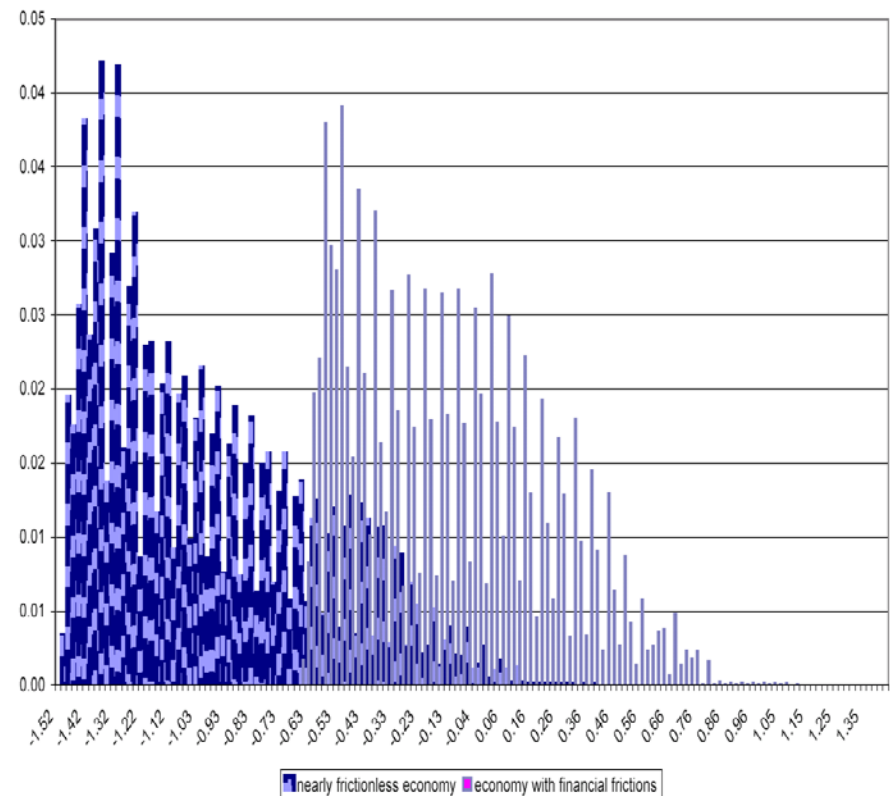
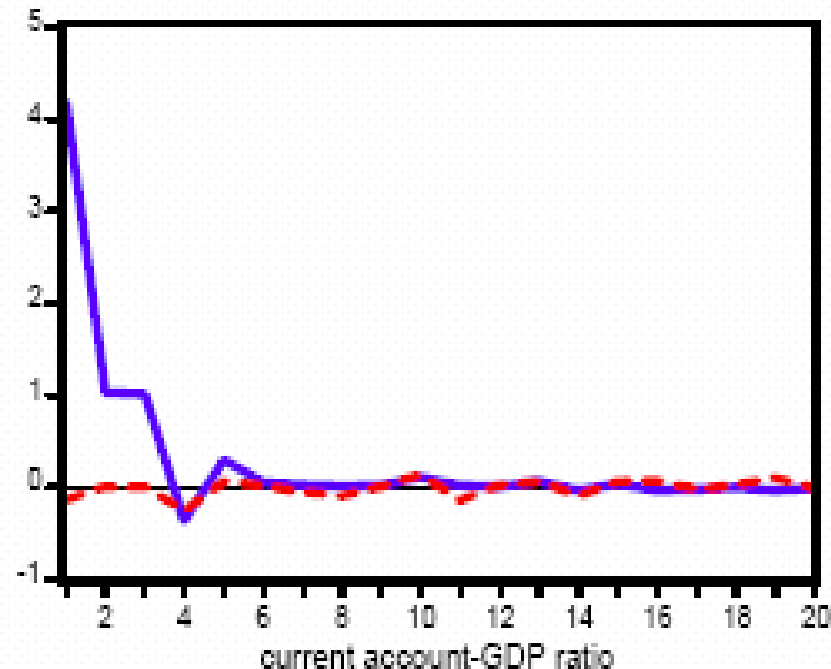
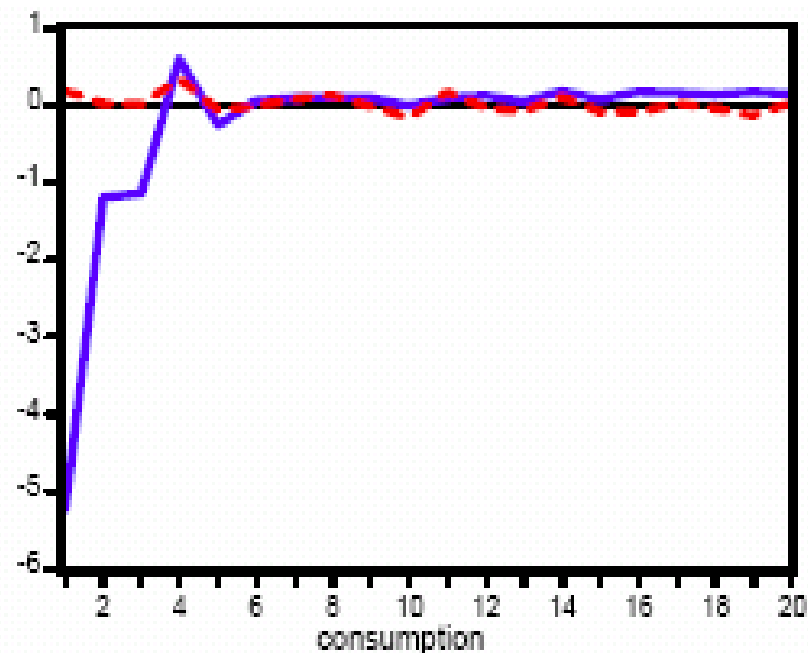


Figure 1b. Ergodic Distributions of Bonds



# Crisis responses at high and low leverage ratios

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



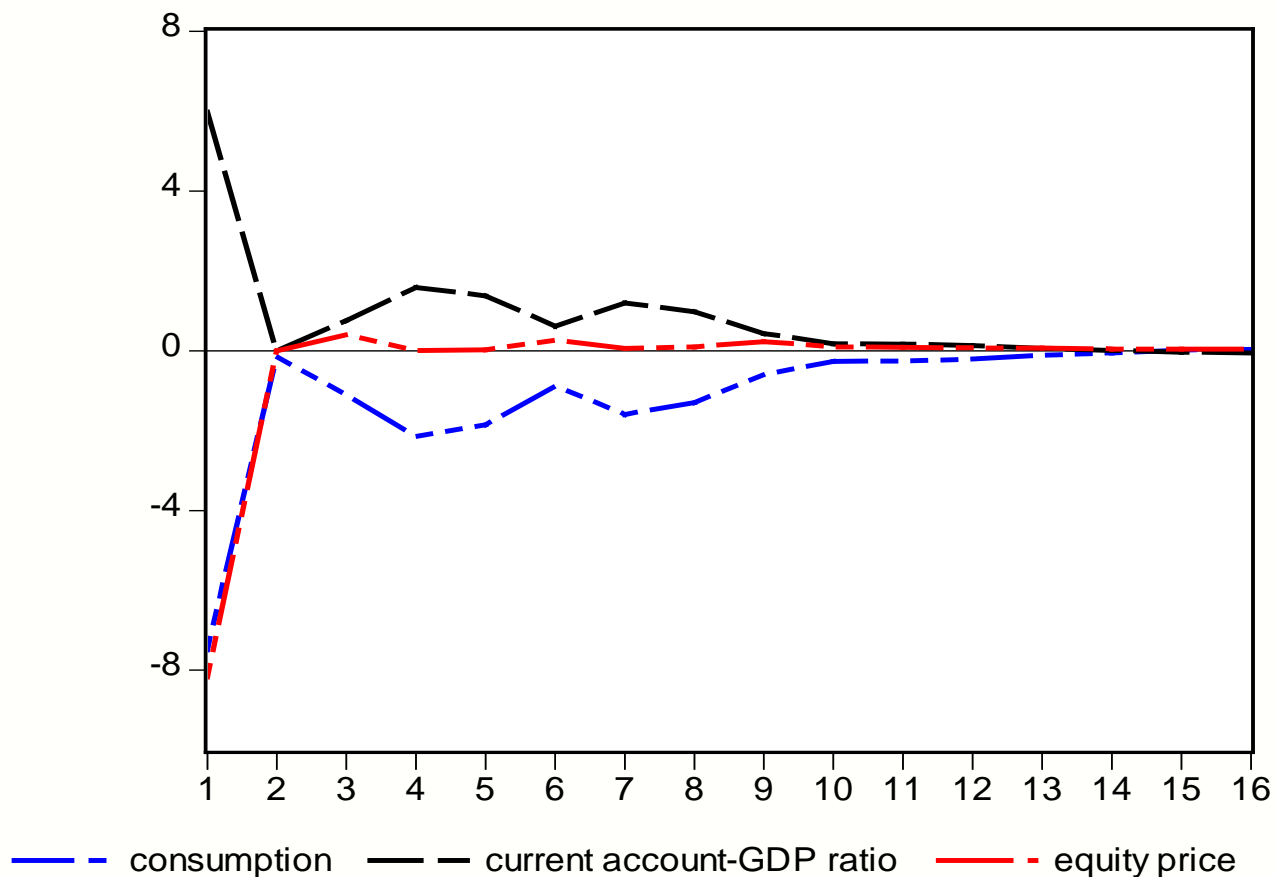
■ high leverage ratio (-10.9%)    ■ low leverage ratio (-7.4%)

High leverage state:  $\alpha=0.806$ ,  $b=-1.481$ ,  $b/q\alpha=-10.9\%$

Low leverage state:  $\alpha=0.806$ ,  $b=-1.01$ ,  $b/q\alpha=-7.4\%$

# Crisis responses: low foreign demand elasticity ( $1/2$ )

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) .

## Model 3: Crises in Business Cycle Model (*Mendoza, AER 10*)

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

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

subject to

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

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

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

# Main findings

- Long-run business cycle moments unaffected by credit constraints
  - Financial crises nested with normal cycle
  - Prec. savings reduces prob. of crises ( $\kappa=0.2$  calibrated to match actual frequency of SS events)
- Constraints bind 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 in 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

# Calibration

## Parameters set with ratios from data and deterministic steady state conditions

$\alpha$	0.592	labor share set to yield 0.66 share in GDP as $\alpha/(1-\eta)$
$\beta$	0.306	capital share set to yield 0.33 share in GDP as $\beta/(1-\eta)$
$\delta$	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
$\gamma$	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)

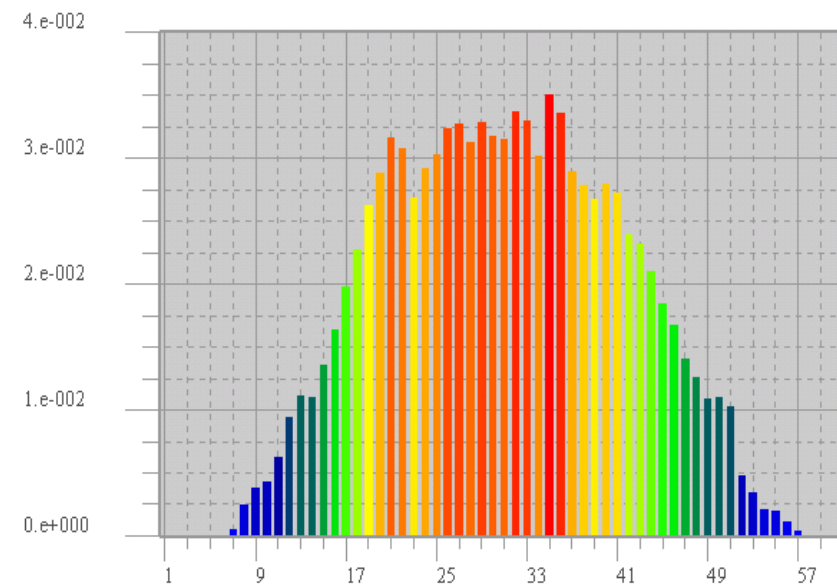
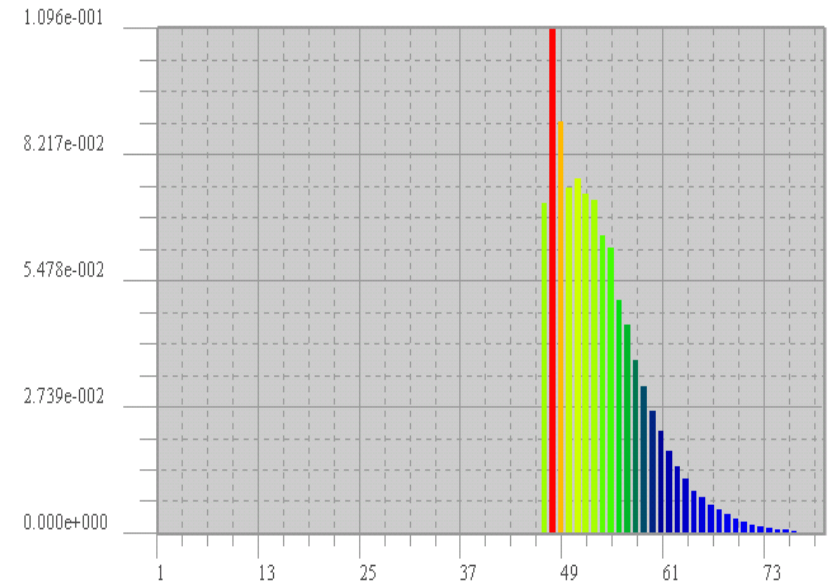
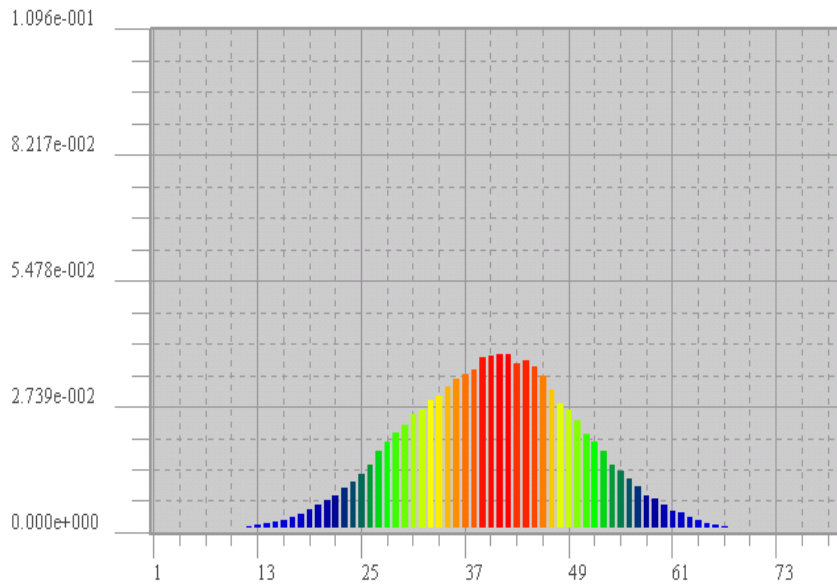
$\eta = pv/y$	0.102	imported inputs/gross output ratio
$k/y$	1.758	capital/gross output ratio
$pv/gdp$	0.114	imported inputs/gdp ratio
$gdp/y$	0.896	gdp/gross output ratio
$c/gdp$	0.65	consumption/gdp ratio
$g/gdp$	0.110	gov. purchases/gdp ratio
$i/gdp$	0.172	investment/gdp ratio
$g/c$	0.168	ratio of public to private consumption

## Parameters set with SMM

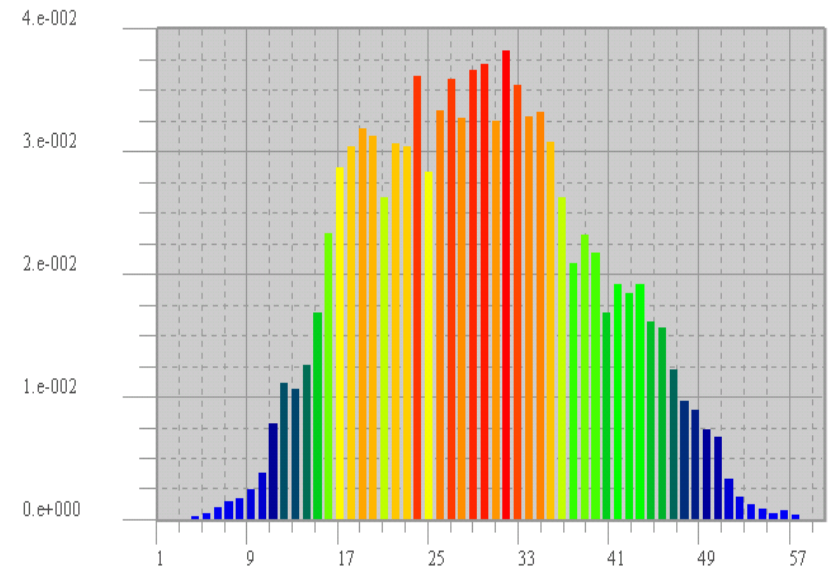
$a$	2.75	targeted to match ratio of s.d. of investment to s.d. of gdp
$\phi$	0.2579	targeted to yield a mean working capital/gdp ratio of 0.2

# Stochastic steady states

net foreign assets



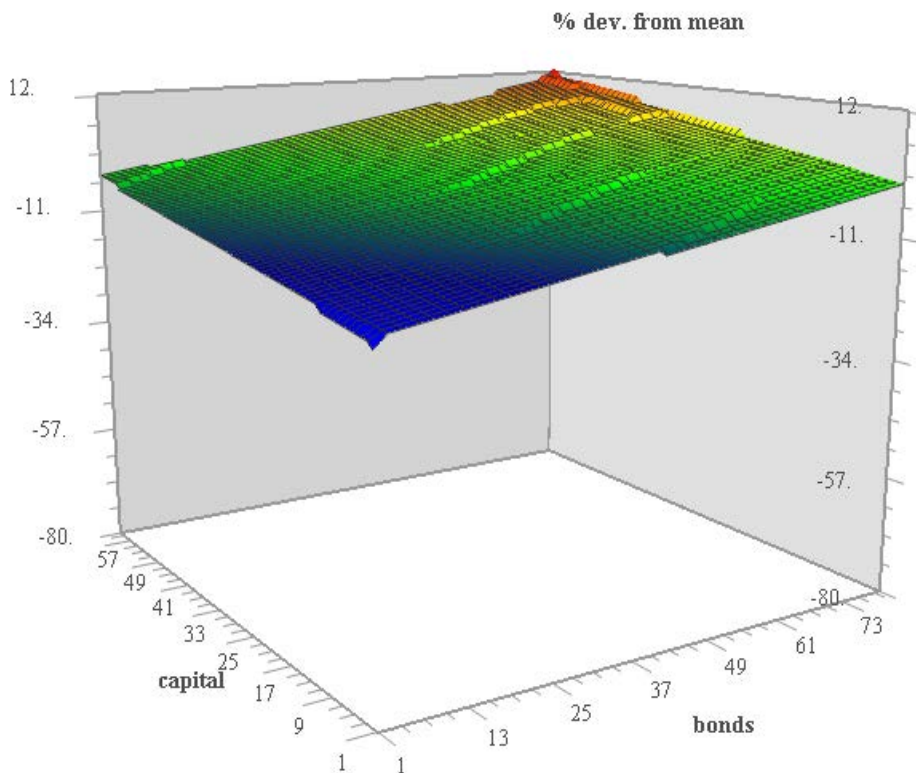
capital



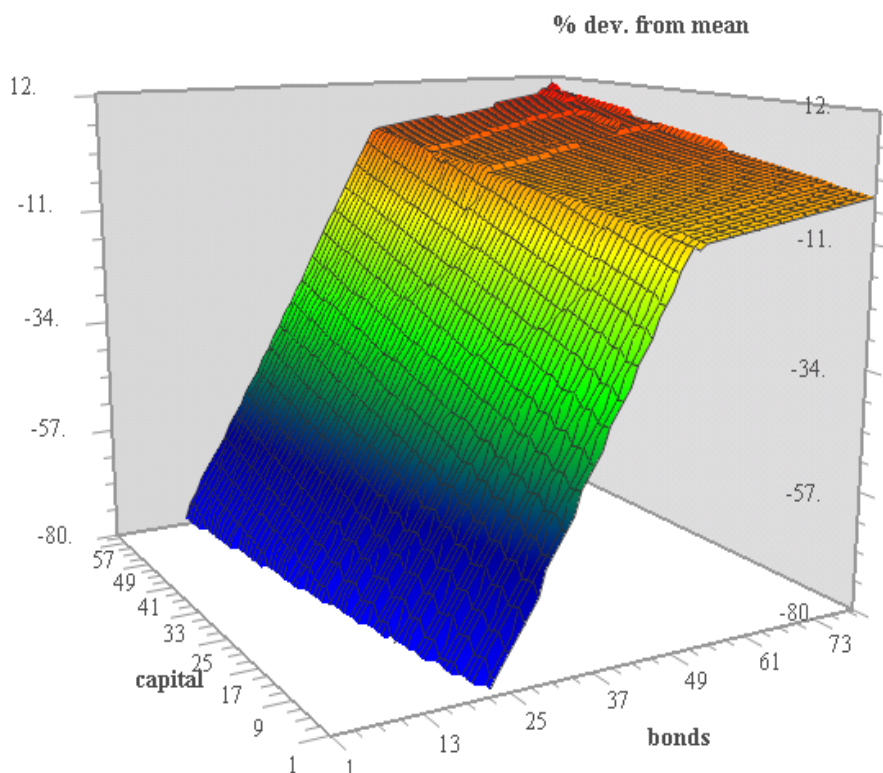


# Universe of consumption impact effects

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



**Perfect credit markets**



**Economy with collateral constraint**

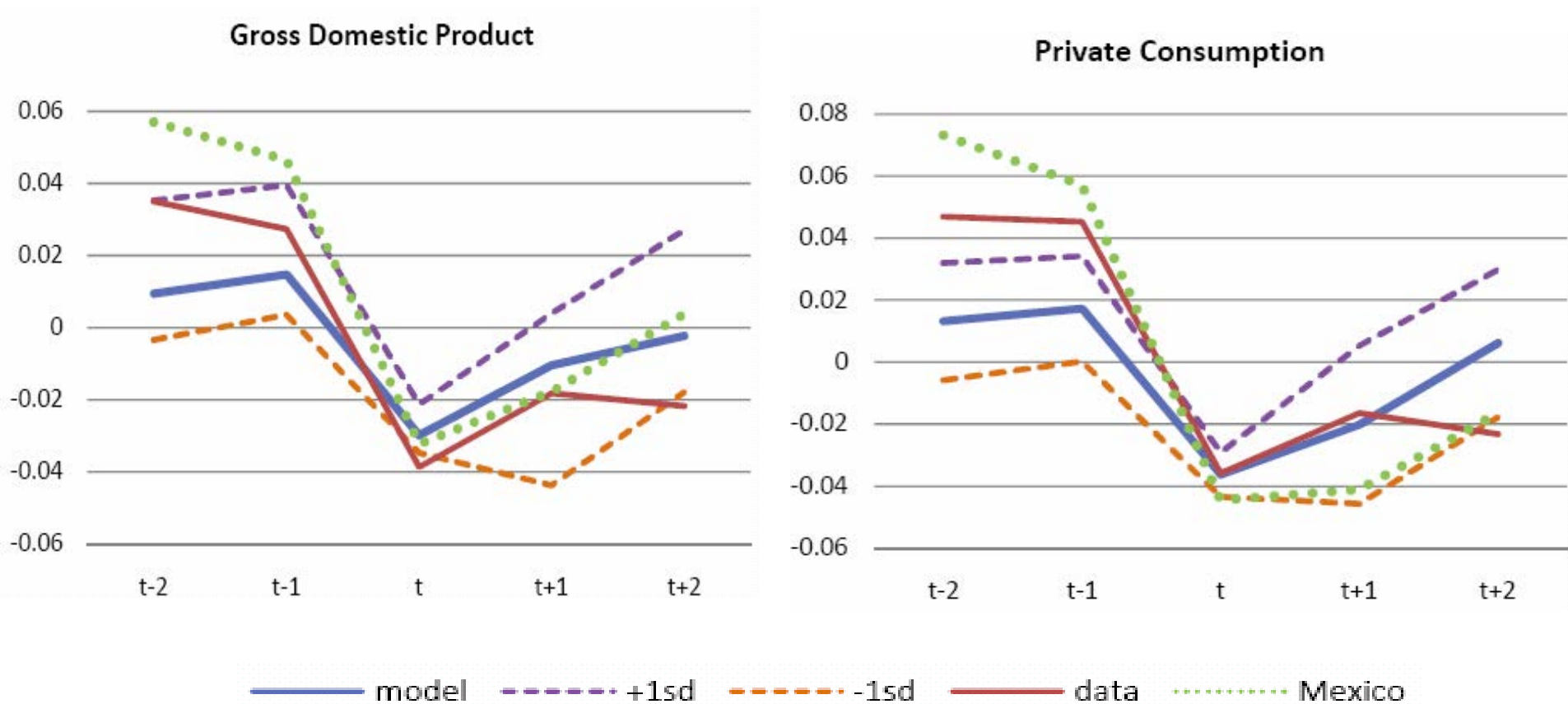


# Amplification & Asymmetry Features of Crises

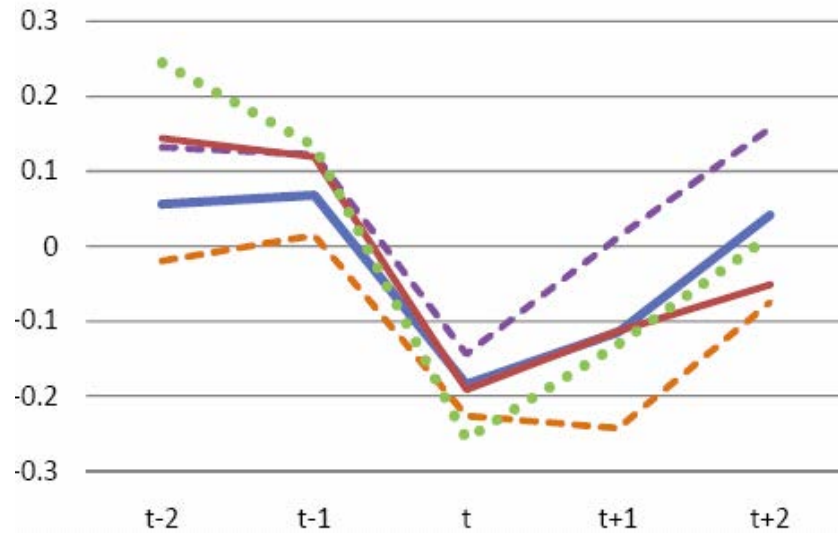
(mean excess responses relative to frictionless economy in percent of frictionless averages)

	(1) baseline economy $\kappa=0.20$		(2) lower collateral coefficient $\kappa=0.30$		(3) higher collateral coefficient $\kappa=0.15$		(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
<i>gdp</i>	-1.13	-0.11	-1.18	-0.06	-1.21	-0.14	-0.86	-0.06	0.00	0.00
<i>c</i>	-3.25	-0.31	-3.17	-0.14	-3.15	-0.42	-2.12	-0.23	-1.54	-0.34
<i>i</i>	-11.84	-0.61	-10.73	-0.18	-12.35	-0.91	-7.48	-0.30	-9.71	-1.25
<i>q</i>	-2.88	-0.15	-2.64	-0.04	-2.99	-0.22	-1.81	-0.07	-2.53	-0.31
<i>nx/gdp</i>	3.56	0.25	3.32	0.08	3.47	0.34	2.13	0.17	3.11	0.49
<i>b/gdp</i>	3.57	0.25	3.00	0.06	3.60	0.36	2.11	0.18	3.31	0.53
<i>lev. ratio</i>	1.31	0.12	0.89	0.04	1.47	0.18	0.83	0.09	0.90	0.17
<i>L</i>	-1.71	-0.16	-1.79	-0.09	-1.83	-0.22	-1.29	-0.10	0.00	0.00
<i>v</i>	-3.10	-0.29	-3.21	-0.16	-3.31	-0.40	-2.36	-0.18	0.00	0.00
<i>w. cap.</i>	-3.12	-0.29	-3.25	-0.16	-3.34	-0.40	-2.37	-0.18	na	na
<i>R</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>p</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>tfp</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<i>prob. of SS events</i>	3.32%		1.07%		3.92%		9.54%		0.07%	
<i>b/gdp in SS events</i>	-0.21		-0.44		-0.17		-0.20		-0.40	

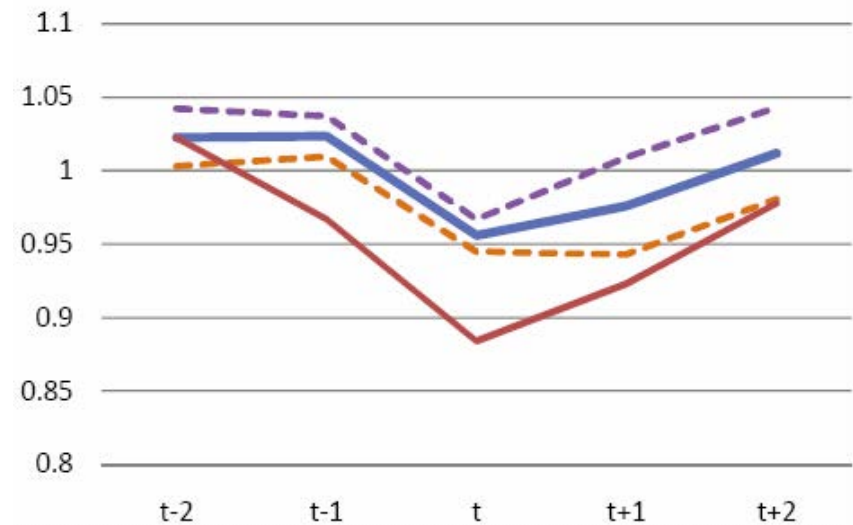
# Financial crises events in the data and in the model



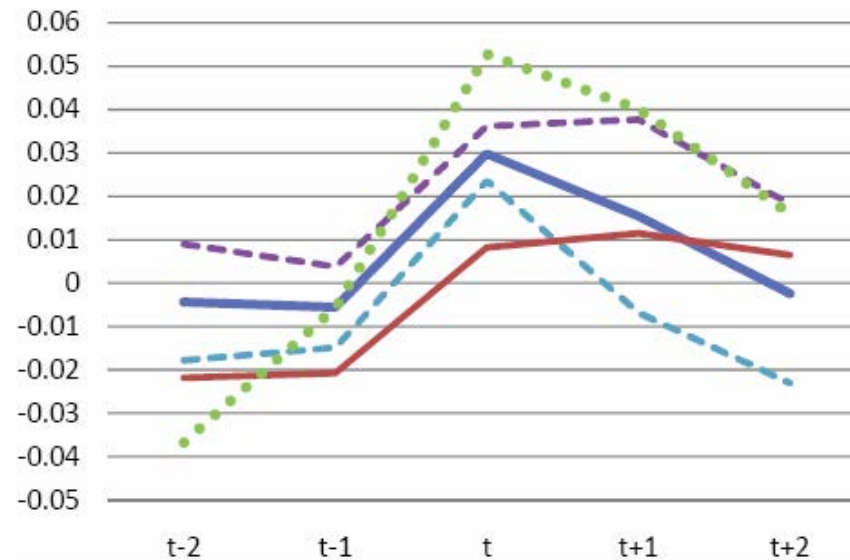
Investment



Tobin Q



Net exports-GDP ratio



— model    - - - +1sd    - - - -1sd    — data    ..... Mexico



## **6. CONCLUSIONS & POLICY LESSONS**



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## Conclusions & policy lessons

- Endogenous financial crises nested with normal cycles & caused by normal shocks in highly-leveraged economies
  - Constraints cause output collapse, large amplification & asymmetry
    - Amplification driven by Fisher's debt deflation
  - Eliminating financial crises requires addressing contractual frictions (i.e. financial development)
    - Ad-hoc capital requirements poor safeguard against aggregate risk
  - ...but policy can be useful/effective taking those frictions as given:
    - *Neo-Mercantilism*: "war chest" of reserves to fight financial crises
    - Stabilize asset prices/liquidity to maintain market access (Calvo (02), Lerrick & Meltzer (02), bankruptcy court, indexed bonds) ...but with moral hazard tradeoffs (Durdu & Mendoza *JIE* (06))
    - Macroprudential policies (Bianchi (10), Bianchi & Mendoza (10,13), Boz et al. (12))...but require precise knowledge of credit dynamics
  - Contagion: shocks can trigger SSs in waves despite fundamentals (Mendoza & Quadrini *JME* (10))
-