Sovereign Debt Issuance and Selective Default

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Motivation (I)

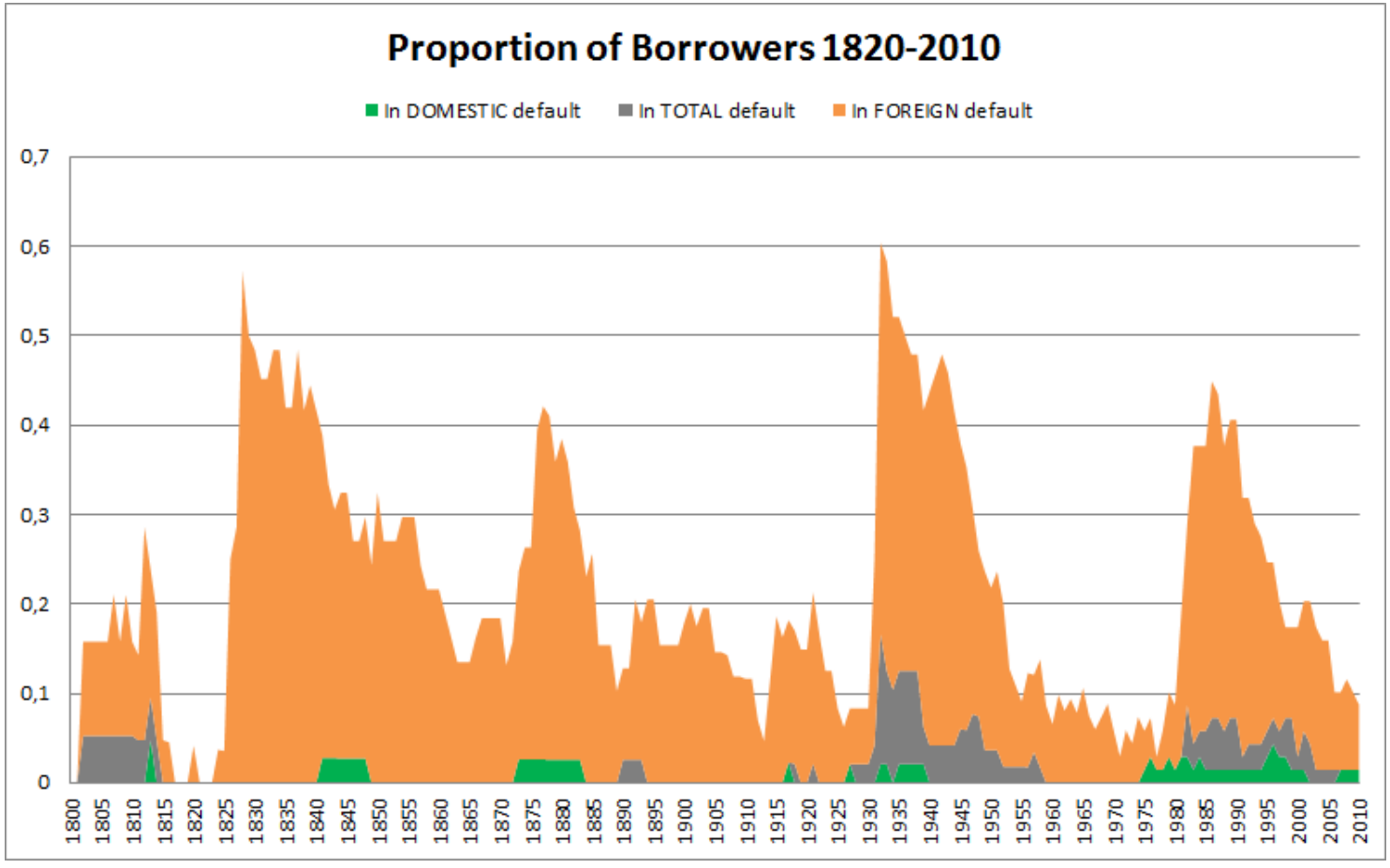
Sovereign default literature:

- Benevolent government borrows on international markets to smooth agents consumption
- And defaults when benefits outweigh costs

What about domestic debt?

- Domestic debt accounts for two-thirds of total debt in EM
- In foreign default: is domestic debt still serviced?
- Or is it also defaulted?

Motivation (II)



- Episodes: 77% foreign, 10% domestic, 13% total
- *De jure* versus *de facto* defaults

Definitions

Domestic vs. foreign debt:

- *Economic* definition: held by residents vs. non-residents
- *Legal* definition: issued according to domestic law vs. law of other country
- *Currency* definition: issued in domestic vs. foreign currency

"The overwhelming majority of external public debt, debt under the legal jurisdiction of foreign governments, has been denominated in foreign currency and held by foreign residents." (R&R 2011)

- *Economic* definition gives differential incentives
- Data on debt available in *economic* and *legal* definition, for defaults in *legal* definition

Research Questions

1. Why do governments accumulate both foreign and domestic debts?

   Hedge against different types of shocks: output and taxation

2. Why do governments default selectively?

   This hedge is imperfect due to incomplete markets and discretion

3. Can secondary markets solve default problem?

   Not necessarily

4. Can the model with two debts reproduce data: debt composition, debt-to-gdp, spreads and frequencies of defaults?

   Yes

Inspirations

Foreign default and commitment problem

- Arellano (2008) Solves commitment problem with exogenous penalties upon default
- Broner, Martin and Ventura (2010) solve commitment problem with Secondary Markets without penalties

Domestic default and distortionary taxation

- Pouzo and Presno (2014): Trade-off between default penalties and distortionary taxation

Selective default:

- Erce (2012) and Vasishta (2012)

Intuition

- Government covers expenditure and has three means of financing: taxes, domestic debt, foreign debt
- Markets are incomplete and government acts discretionary
- Output shock
  - Reason to issue foreign debt: smooth output shock
  - Trade-off between capital outflow (repayment) and default penalties
- Tax distortion shock
  - Collecting T amount of taxes requires loss of $T(1+\tau)$ resources for households
  - Reason to issue domestic debt: smooth tax distortions
  - Domestic debt attractive when tax collection inefficient

Two Period Model

Two Period Example

- Government expenditures only in 1st period $g_1 = g > 0$
- Shocks only in the 2nd period: $y_2 = \{y_l, y_h\}$ and $\tau_2 = \{\tau_l, \tau_h\}$
- In 1st period output is high $y_1 = y_h$ and taxes are non-distortive $\tau_1 = 0$
- No inherited debts $b_{h0} = 0$ and $b_{f0} = 0$
- Output penalty upon default $y(1 - \delta^i)$
- Solve by backward induction: default schedule in 2nd period and debt policies in 1st period
- Following *Broner, Martin and Ventura, AER 2010*

Equilibrium

Equilibrium in the two period economy with discretionary government and foreign and domestic investors is:
(i) domestic b_h and foreign b_f issuances in the first period
(ii) domestic d_h and foreign d_f default decisions in the second period
(iii) bond disount prices q_h and q_f
such that:
1) Taking as given d_h, q_h and b_h households' consumption c satisfies budget constraint and FOC
2) Taking as given d_f price of foreign bond q_f is consistent with foreign investors expected zero profits
3) Taking as given q_h and q_f default decisions d_h, d_f and debt policies b_h, b_f satisfy government budget constraint and solve government optimization problem

2nd Period

- In 2nd period: no demand for bonds
- On domestic market: to repay b_h in taxes yields net loss of τb_h
- Compare consumptions in four scenarios:

$$\begin{aligned} c^r &= y_2 - b_f(1+\tau_2) - b_h\tau_2 \\ c^{fd} &= y_2(1-\delta^f) - b_h\tau_2 \\ c^{hd} &= y_2(1-\delta^h) - b_f(1+\tau_2) \\ c^{td} &= y_2(1-\delta^h)(1-\delta^f) \end{aligned}$$

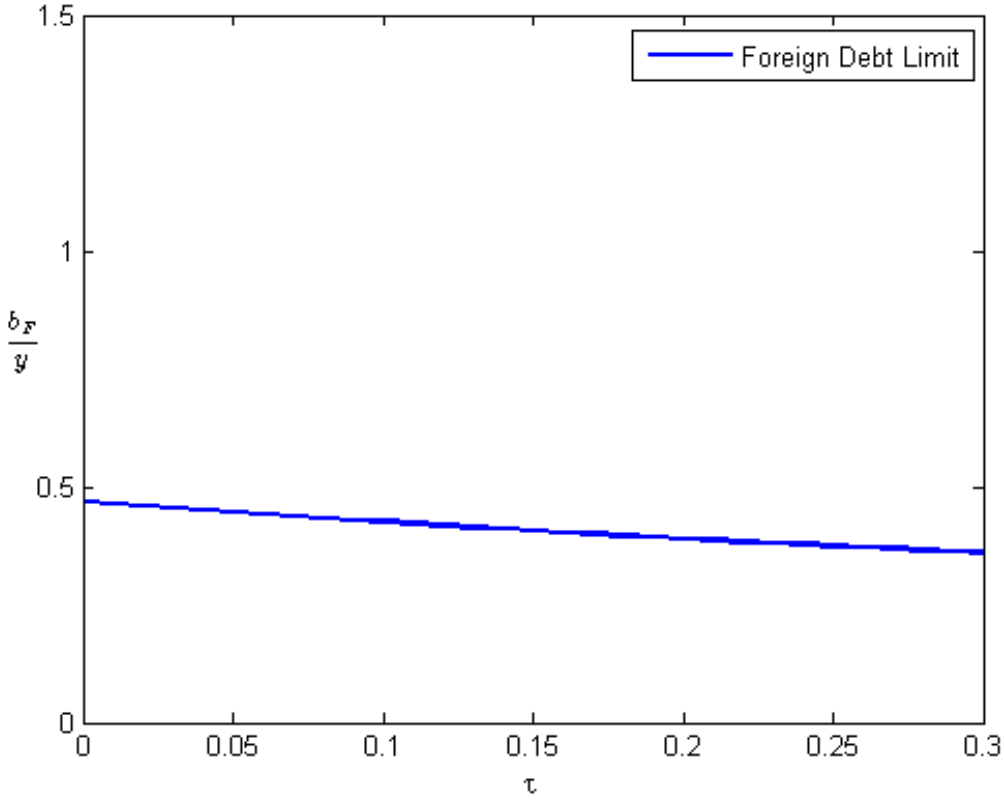
Foreign debt sustainability limit:

$$\frac{b_f}{y_2} \leq \frac{\delta^f}{1+\tau_2} \tag{1}$$

Domestic debt sustainability limit:

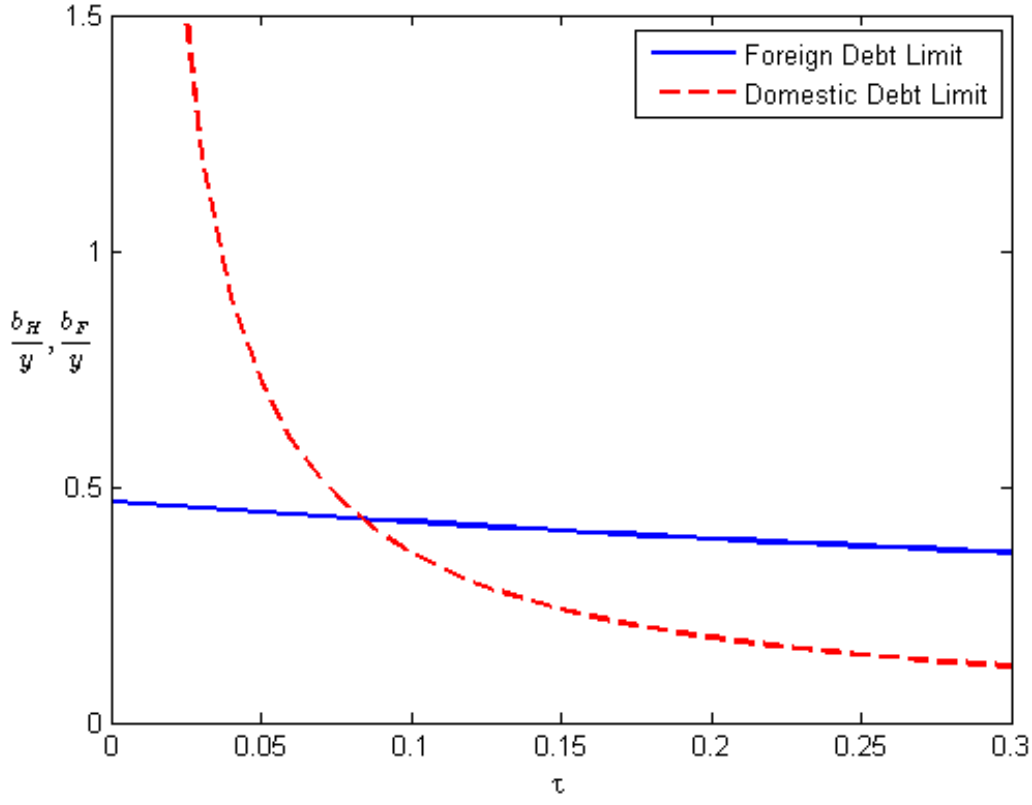
$$\frac{b_h}{y_2} \leq \frac{\delta^h}{\tau_2} \tag{2}$$

2nd Period



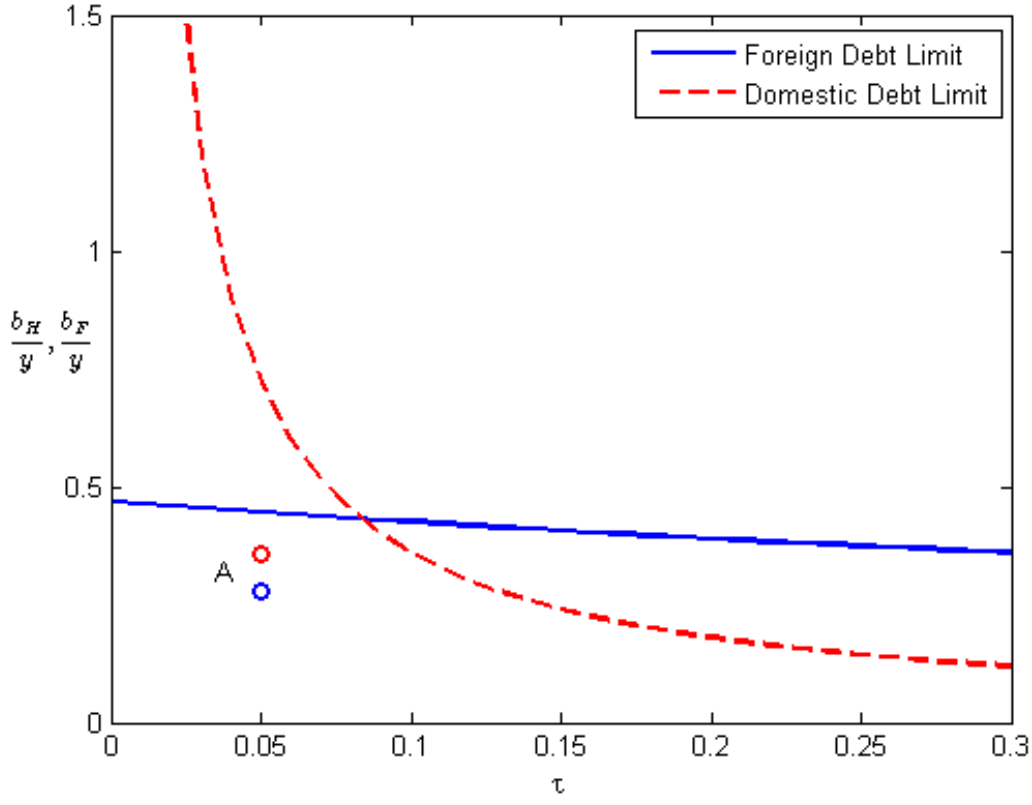
$$\frac{b_f}{y_2} = \frac{\delta^f}{1+\tau_2}$$

2nd Period



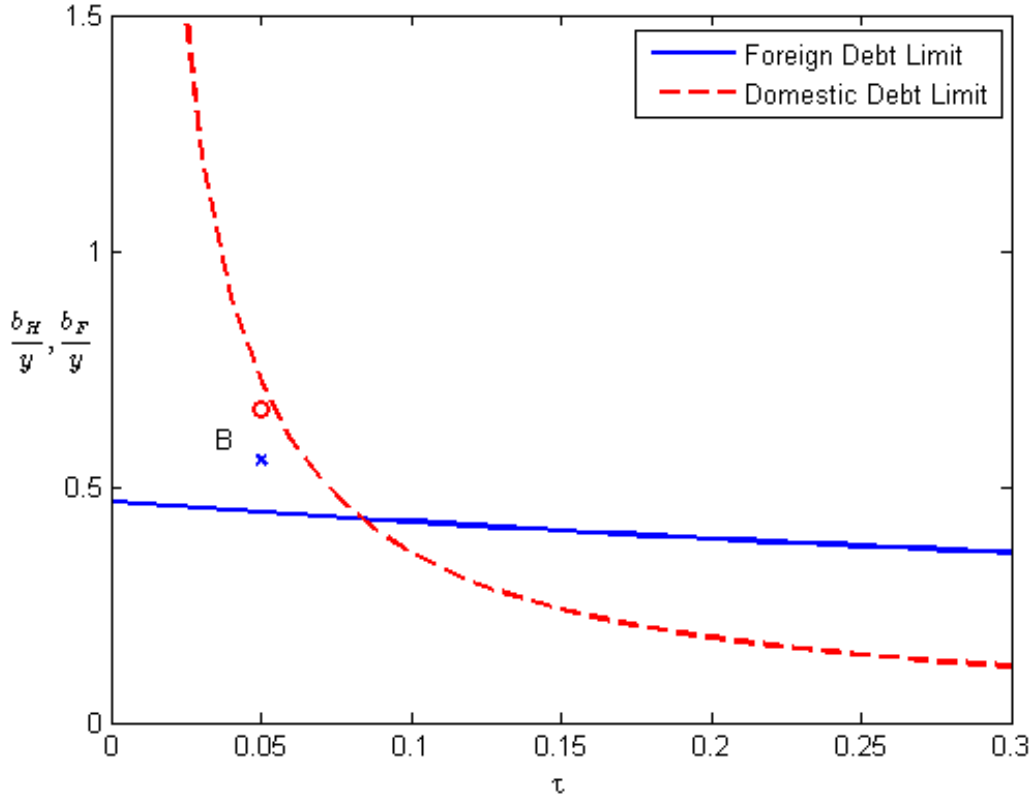
$$\frac{b_f}{y_2} = \frac{\delta^f}{1+\tau_2} \qquad \frac{b_h}{y_2} = \frac{\delta^h}{\tau_2}$$

2nd Period



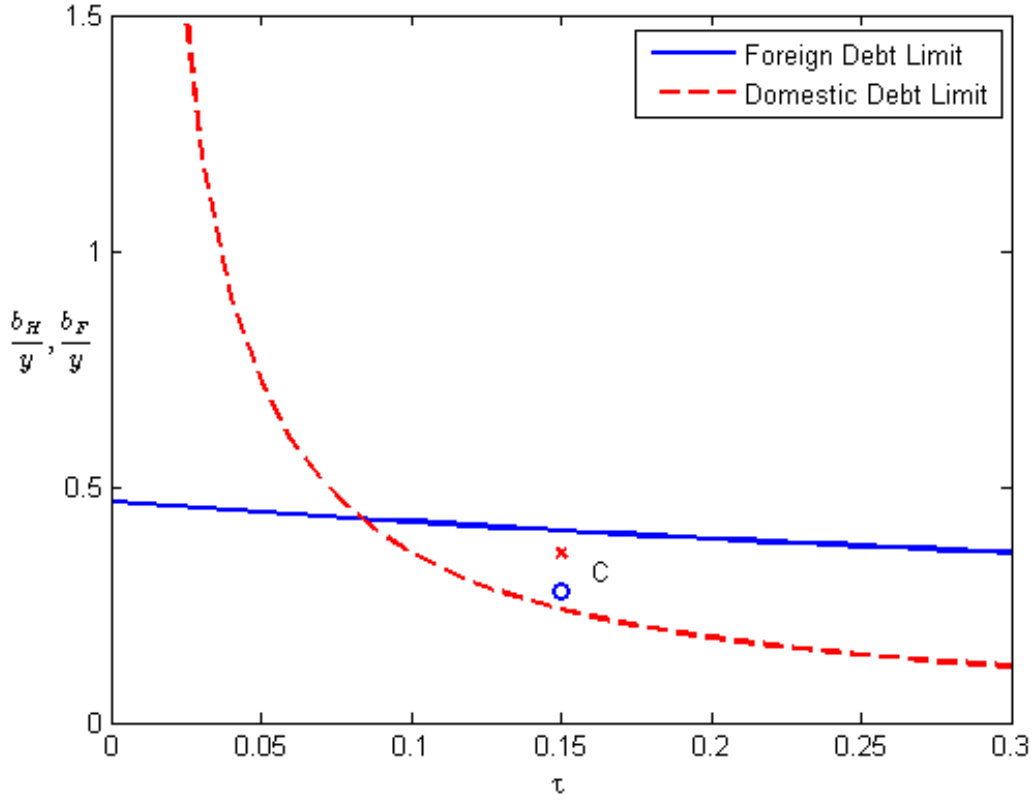
$$\frac{b_f}{y_h} \leq \frac{\delta^f}{1+\tau_l} \qquad \frac{b_h}{y_h} \leq \frac{\delta^h}{\tau_l}$$

2nd Period



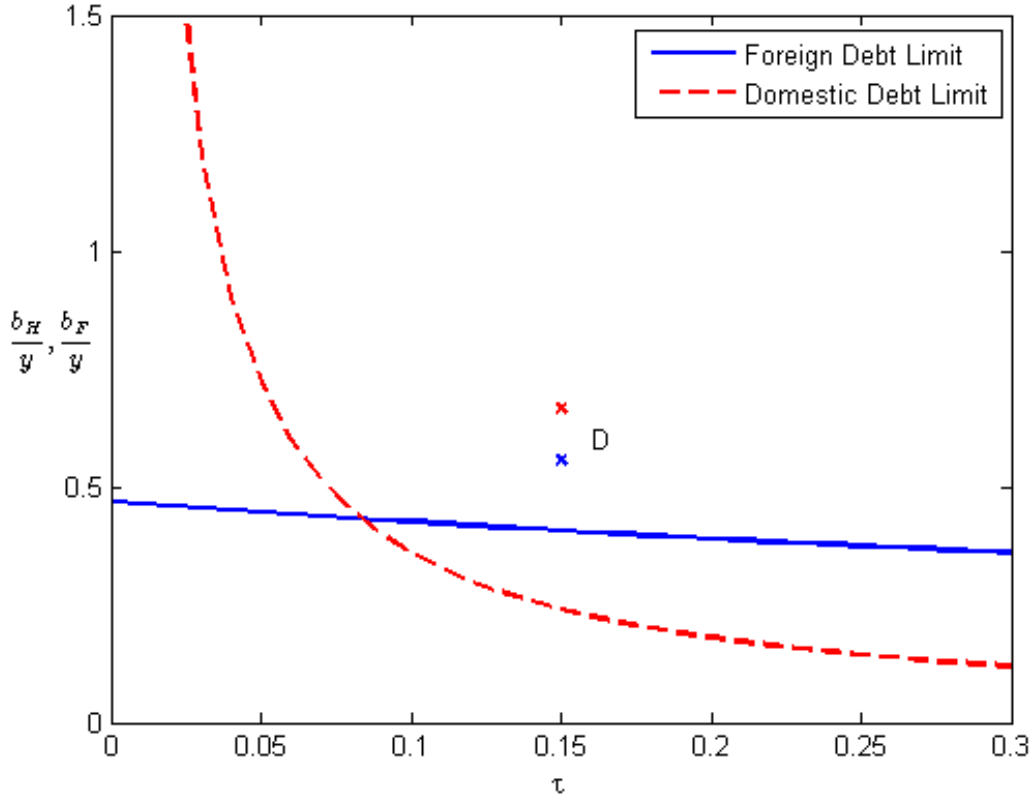
$$\frac{b_f}{y_l} > \frac{\delta^f}{1+\tau_l} \qquad \frac{b_h}{y_l} \leq \frac{\delta^h}{\tau_l}$$

2nd Period



$$\frac{b_f}{y_h} \leq \frac{\delta^f}{1+\tau_h} \qquad \frac{b_h}{y_h} > \frac{\delta^h}{\tau_h}$$

2nd Period



$$\frac{b_f}{y_l} > \frac{\delta^f}{1+\tau_h} \qquad \frac{b_h}{y_l} > \frac{\delta^h}{\tau_h}$$

2nd Period

$$\frac{b_h}{y_2} \leq \frac{\delta^h}{\tau_2} \qquad \frac{b_f}{y_2} \leq \frac{\delta^f}{1+\tau_2}$$

Propositions

1. If taxation is costless any level of domestic debt is sustainable in repayment equilibrium (BMV 2010, *AER*)
2. If taxation is costly there is finite limit to domestic debt sustainable in repayment equilibrium
3. If taxation distortion is stochastic both domestic and foreign debt limit can be broken

Guess and verify:

$$\frac{y_l \delta^f}{1+\tau_l} < b_f \leq \frac{y_h \delta^f}{1+\tau_h} \tag{3}$$

$$\frac{y_h \delta^h}{\tau_h} < b_h \leq \frac{y_l \delta^h}{\tau_l} \tag{4}$$

1st Period

Government:

- Takes issuance decisions b_h, b_f
- To maximize lifetime utility of domestic agents
- Assuming (3) and (4) hold
- Subject to: HHs budget constraint, resource constraint, foreign debt price schedule and HHs FOC (domestic price schedule)

Equilibrium:

- Debt issuances b_h, b_f satisfy (3) and (4)

Comparative statics:

1. Negative correlation between spread and fraction of foreign investors
2. Positive correlation between debt-to-gdp and fraction of domestic investors

Quantitative Model

Motivation

Quantitative sovereign default models:

- Match frequency of foreign defaults
- Replicate stylized facts of business cycle of emerging economies well
- Hard time to match debt-to-GDP ratios *(Chatterjee and Eyigungor, AER 2012)*
- Cannot explain foreign, domestic and total default frequencies jointly
- Don't look at debt composition

Methodological contribution:

- Default risk pricing with risk-averse domestic investors *(Lizarazo, JIE 2013)*

Households and Foreign Investors

Households maximize utility:

$$\sum_{t=0}^{\infty} \beta^t \frac{c_t^{1-\sigma}}{1-\sigma}$$

subject to:

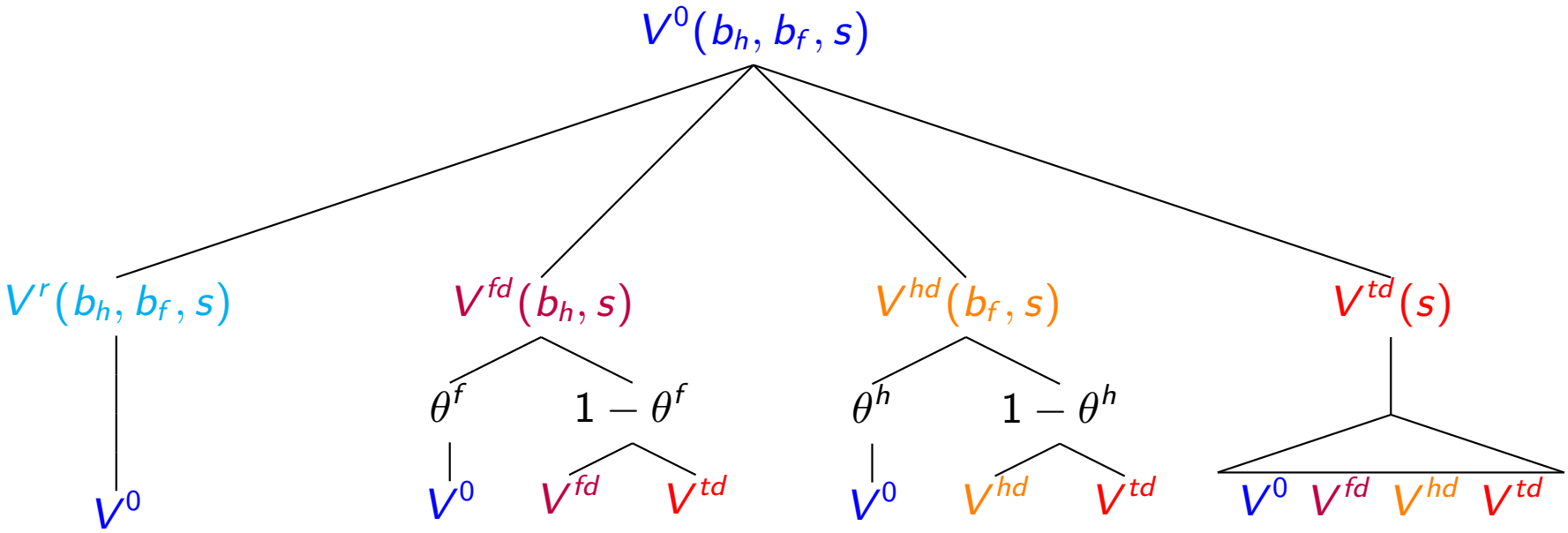
$$c = y(h^f, h^h) - T(1+\tau) + (1-h^h)(b_h - q_h b_h')$$

Foreign investors break even in expectation:

$$q_f = \frac{(1-\Delta^f)}{1+r}$$

Government (I)

States: $S = (b_h, b_f, s)$ and $s = (y, \tau)$



Government (II)

States given by: $S = (b_h, b_f, s)$ and $s = (y, \tau)$

$$V^0(b_h, b_f, s) = max\{V^r(b_h, b_f, s), V^{fd}(b_h, s), V^{hd}(b_f, s), V^{td}(s)\}$$

$$V^r(b_f, b_h, s) = \max_{b'_f, b'_h} \Big\{ u(c^r) + \beta \mathbb{E}\big\{ V^0(b'_f, b'_h, s') \big\} \Big\}$$

subject to: HH BC

$$q_f(b'_h, b'_f, s) = \frac{\mathbb{E}\{1 - d^f(S')\}}{1 + r} \qquad \text{(FPC)}$$

$$q_h(b'_h, b'_f, s) = \beta \frac{\mathbb{E}\Big\{(1 - d^h(S'))u'(c'(S'))\Big\}}{u'(c(S))} \qquad \text{(HH FOC)}$$

$$T = g + (1 - h^h)(b_h - q_h b'_h) + (1 - h^f)(b_f - q_f b'_f) \qquad \text{(GBC)}$$

Government (III)

$$V^{fd}(b_h, s) = \max_{b_h'} \Big\{ u(c^{fd}) + \beta \mathbb{E} \Big(\theta^f V^0(0, b_h', s') + (1-\theta^f) \max \{ V^{fd}(b_h', s'), V^{td}(s') \} \Big) \Big\}$$

subject to HHs b.c., HHs FOC and IC given $h^h = 0$ and $hf = 1$

$$V^{hd}(b_f, s) = \max_{b_f'} \Big\{ u(c^{hd}) + \beta \mathbb{E} \Big(\theta^h V^0(b_f', 0, s') + (1-\theta^h) \max \{ V^{hd}(b_f', s'), V^{td}(s') \} \Big) \Big\}$$

subject to HHs b.c., FPC and IC given $h^h = 1$ and $h^f = 0$

$$V^{td}(s) = u(c^{td}) + \beta \mathbb{E} \Big(\theta^f \theta^h V^0(0, 0, s) + \theta^f (1-\theta^h) V^{hd}(0, s') + (1-\theta^f) \theta^h V^{fd}(0, s') + (1-\theta^f)(1-\theta^h) V^{fd}(s') \Big)$$

subject to HHs b.c. and IC given $h^h = 1$ and $h^f = 1$

Equilibrium

Recursive equilibrium *in this economy is (i) a set of prices for domestic bond* $q_h(S)$ *and foreign bond* $q_f(S)$*, (ii) government debt policies* $b_h'(S)$ *and* $b_f'(S)$ *and (iii) government default schedules* $d_h(S)$ *and* $d_f(S)$ *such that:*
1) Taking as given domestic bond price schedule $d_h(S)$*and government domestic debt* $b_h'(S)$ *and tax policies consumption* $c(S)$ *satisfies households budget constraint and first order condition*
2) Taking as given government foreign default schedule d_f *prices* $q_f(S)$ *are consistent with foreign investors expected zero profits*
3) Taking as given prices $q_h(S)$ *and* $q_f(S)$ *governments default schedules* $d_h(S)$ *and* $d_f(S)$ *and debt policies* $b_h'(S)$ *and* $b_f'(S)$ *solve government optimization problem*

4) Government bond and tax policies and default schedules satisfy implementability constraint

Solution Algorithm

1. Guess price schedules $q_f^0, q_h^0, q_f^{hd0}, q_h^{fd0}$
2. Calculate consumption in autarky and value of autarky c^{aut} and V^{aut}
3. Guess four value functions V^{00}, V^{0fd}, V^{0hd} and V^{0td} using V^{aut}
   - Calculate optimal policies b_f', b_h' in repayment given V^{00} and prices
   - Calculate value of repayment V^r given b_h', b_f', V^{00}
   - Repeat previous steps to get V^{1fd} and V^{1hd}
   - Calculate V^{1td} given V^{1fd} and V^{1hd} and V^{00}
   - Derive optimal default policies d and new value function V^{10}
   - Substitute $V^{00} = V^{10}$ and repeat until convergence
4. Given d calculate prices of foreign and domestic debt q_f^1 and q_h^1
5. Update prices $q_f^0 = \alpha^f q_f^0 + (1 - \alpha^f) q_f^1$ and $q_h^0 = \alpha^h q_h^0 + (1 - \alpha^h) q_h^1$
6. Repeat steps 2-5 until convergence in prices

Calibration

$$log(y_t) = \rho_y log(y_{t-1}) + u_t \qquad u_t \sim \mathcal{N}(0, \epsilon_y)$$

$$\tau_t = \{\tau_l, \tau_h\} \qquad \text{with transition matrix } \Pi$$

$$y_t^{def} = \min\{y_t, \gamma^i \bar{y}\}$$

Parameters Selected Directly

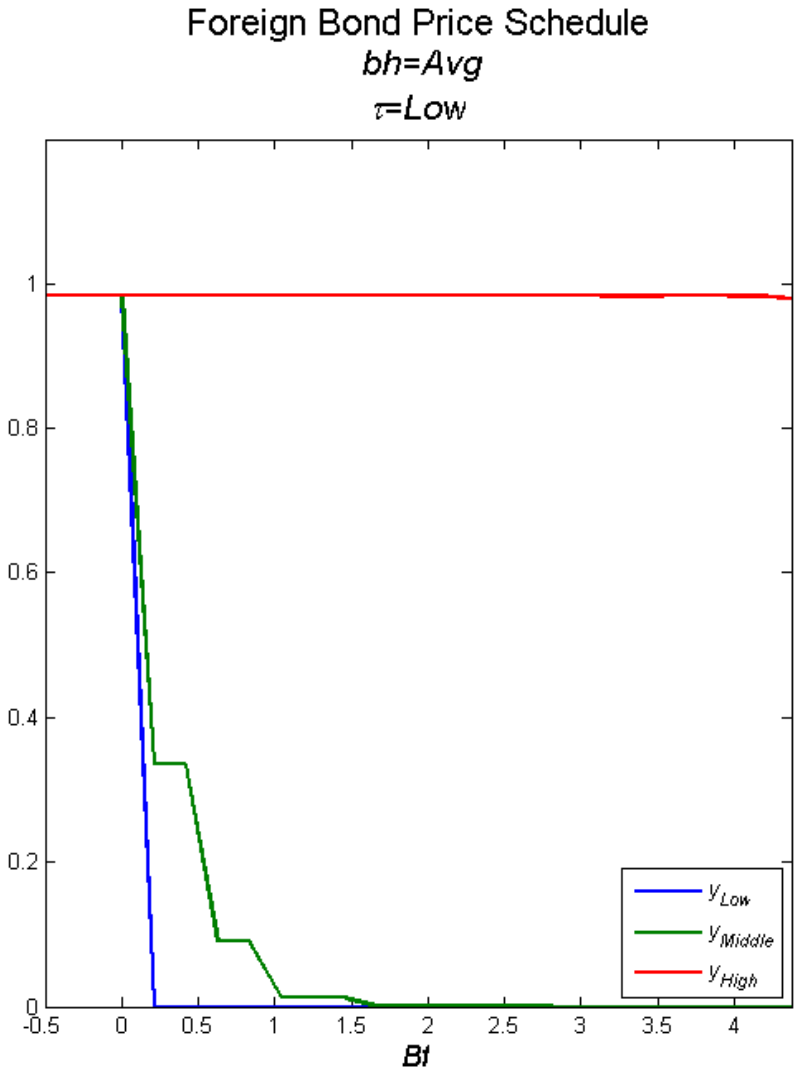
Parameter	Value	Source
Risk-free interest rate	$r = 1.7\%$	US bond yearly yield
Risk aversion	$\sigma = 2$	Standard in literature
Persistence of output	$\rho_y = 0.945$	Argentina 1993-2001
Std. dev. of output	$\epsilon_y = 0.025$	Argentina 1993-2001
Government expenditure	$g/y = 0.25$	Argentina 1993-2001
Re-entry to foreign market	$\theta_f = 0.22$	4.6 yrs. exclusion (R&R 2009)
Re-entry to domestic market	$\theta_h = 0.5$	2 yrs. exclusion (R&R 2009)
Low tax distortion	$\tau_l = 0.01$	Normalized

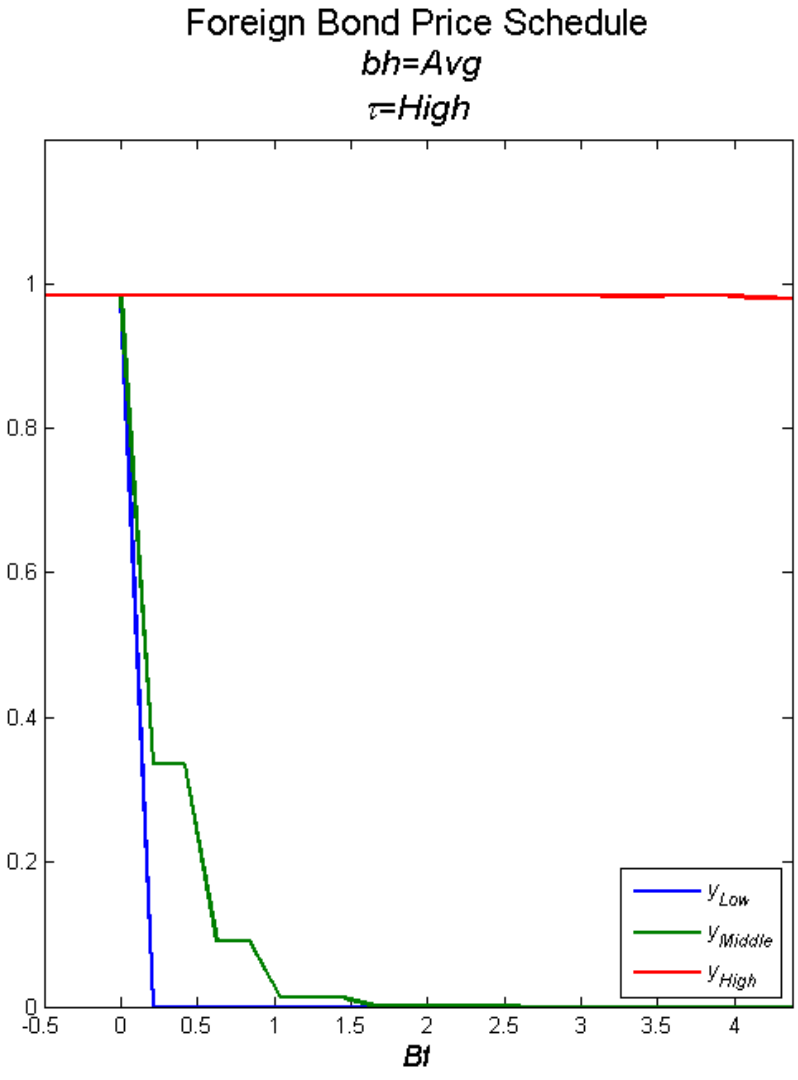
Calibration (II)

Calibrated Parameters

Parameter	Value	Target
Discount factor	$\beta = 0.95$	Debt service to GDP 5.53%
Foreign default output cost	$\gamma_f = 0.97$	F-default frequency 3.5%
Domestic default output cost	$\gamma_h = 0.91$	Output drop after D-default
High tax distortion	$\tau_h = 0.1$	D-debt to GDP 24.8%
High distortion persistence	$\pi_{hh} = 0.7$	D-default freq. 2.5%
Low distortion persistence	$\pi_{ll} = 0.7$	Symmetric $\pi_{hh} = \pi_{ll}$

Prices (I)


Foreign Bond Price Schedule
bh=Avg
τ=Low
1
0.8
0.6
0.4
0.2
0
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
Bf
y_{Low}
y_{Middle}
y_{High}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4
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y_{Low}
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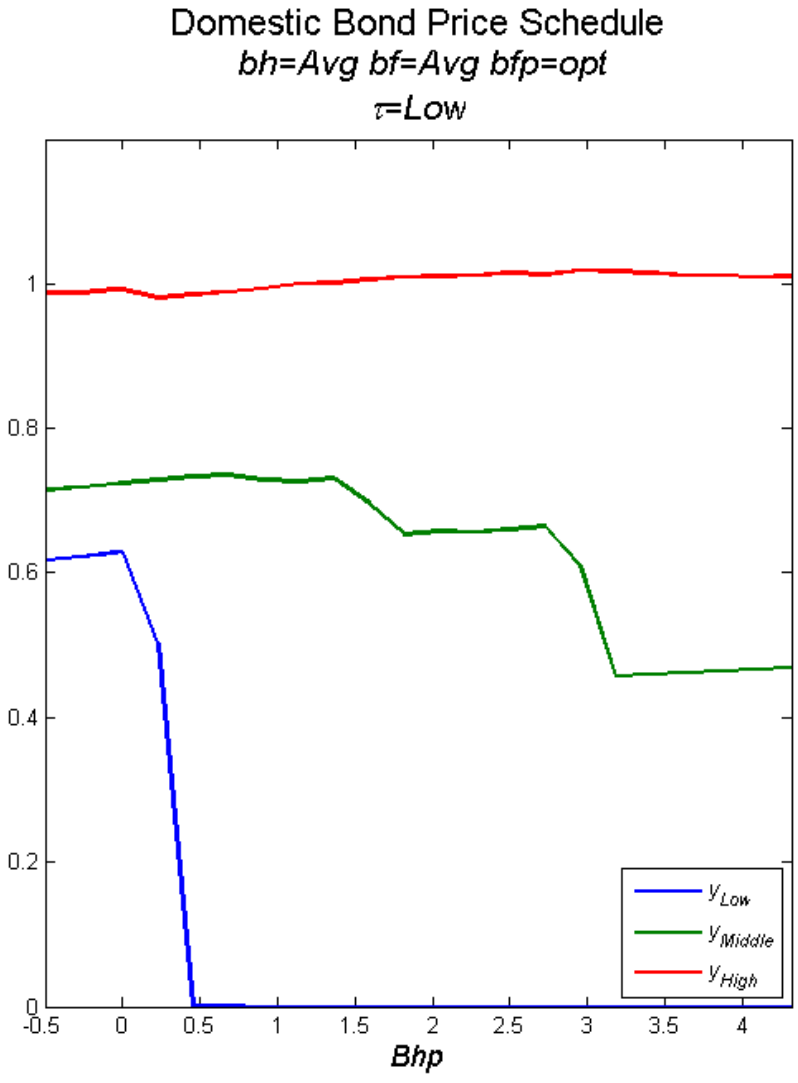
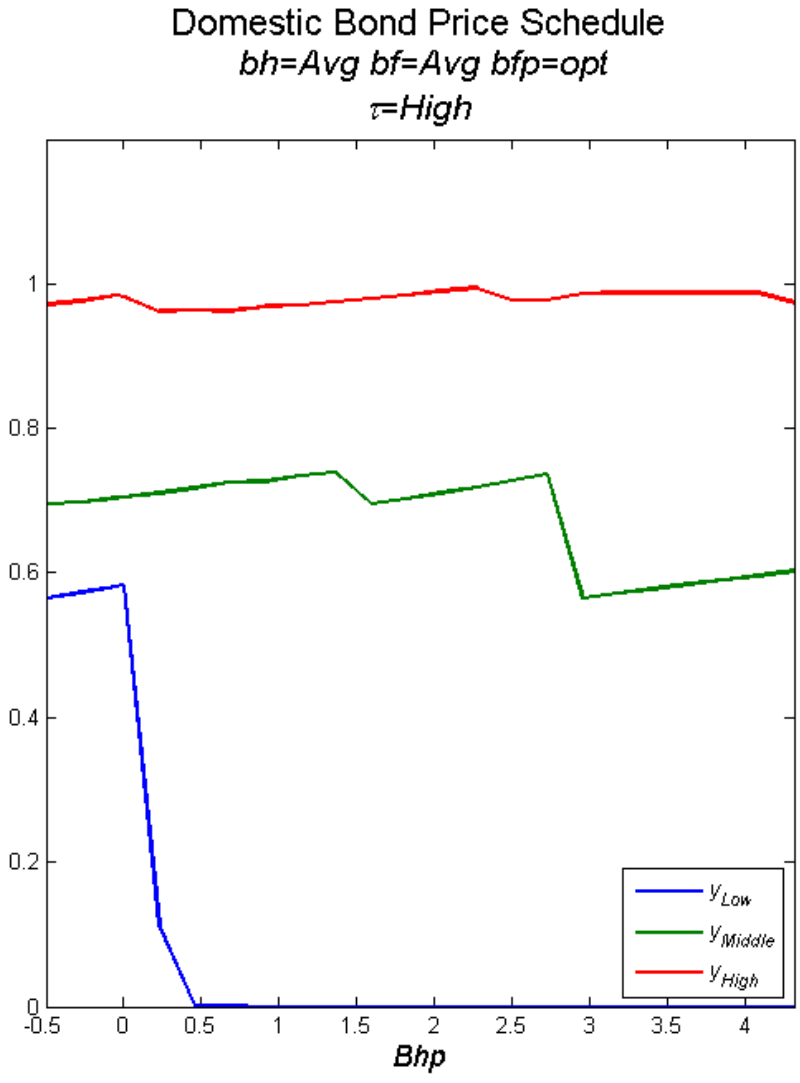
Prices (II)


Domestic Bond Price Schedule
bh=Avg bf=Avg bfp=opt
τ=Low
1
0.8
0.6
0.4
0.2
0
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
Bhp
y_Low
y_Middle
y_High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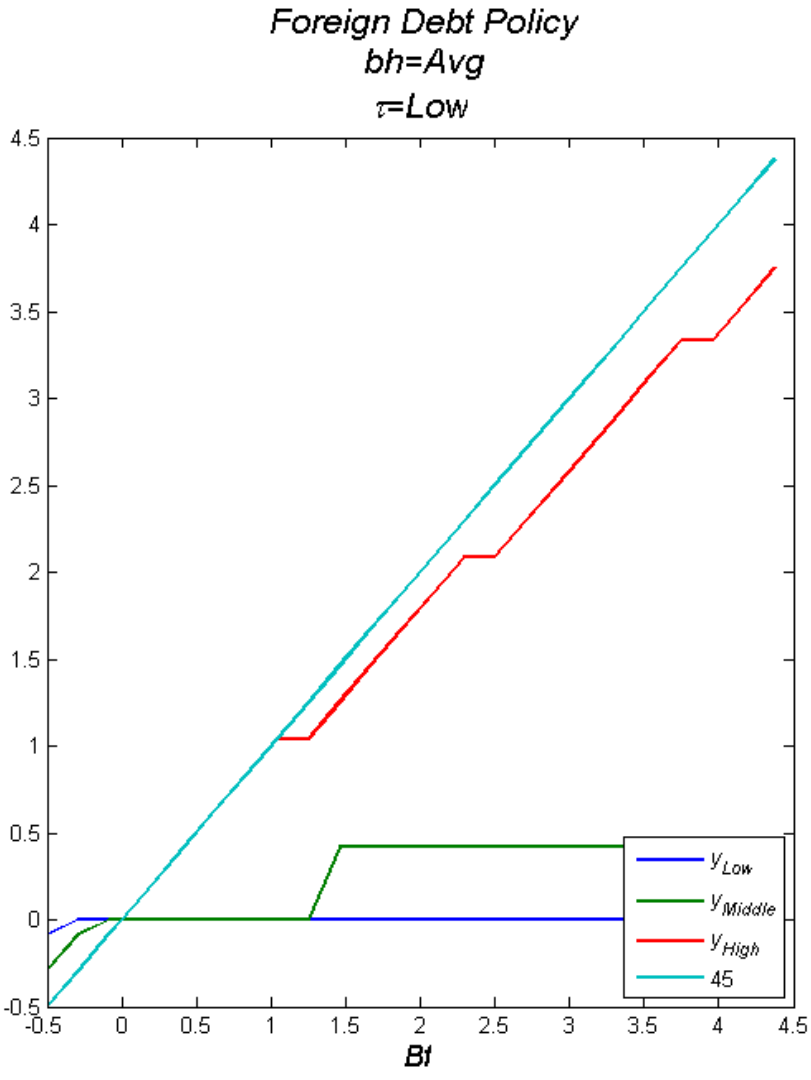
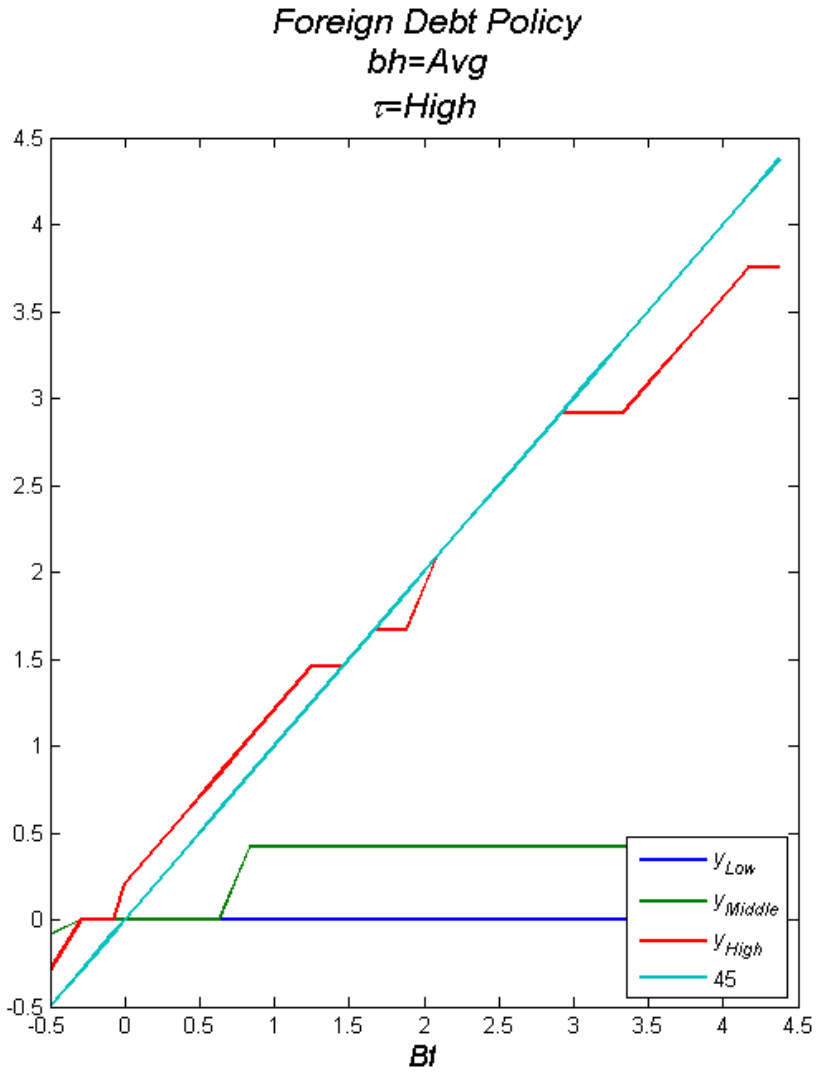
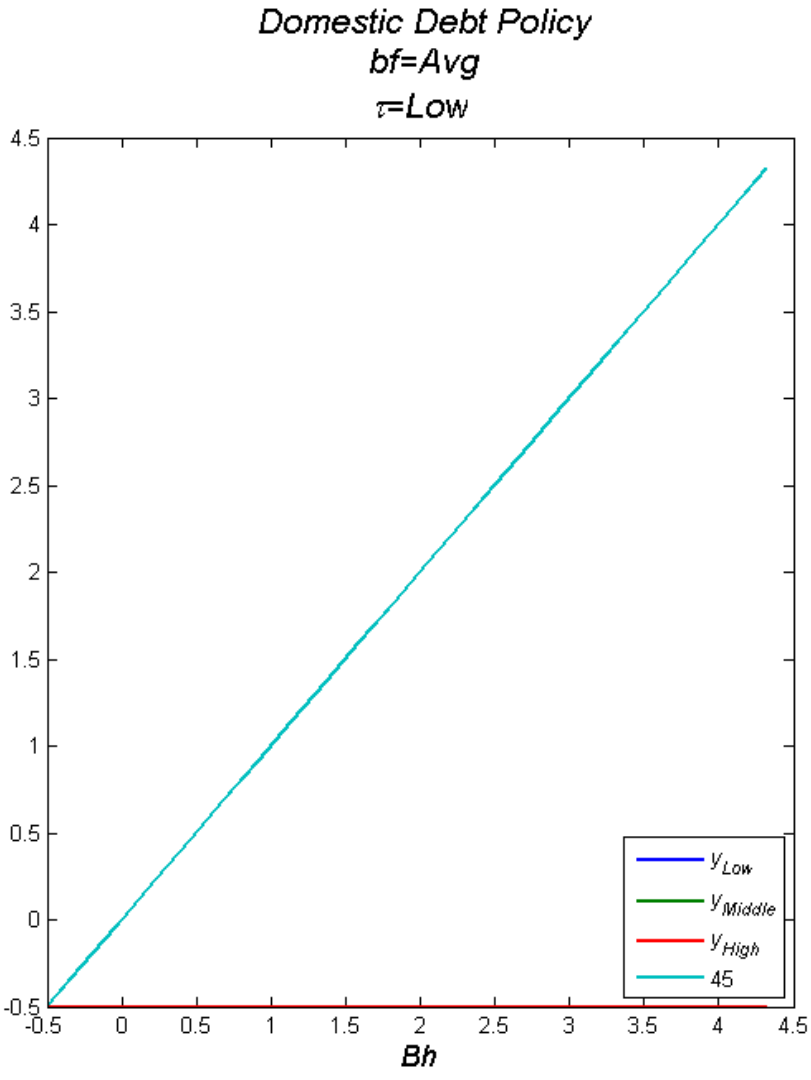
Bhp
y_Low
y_Middle
y_High

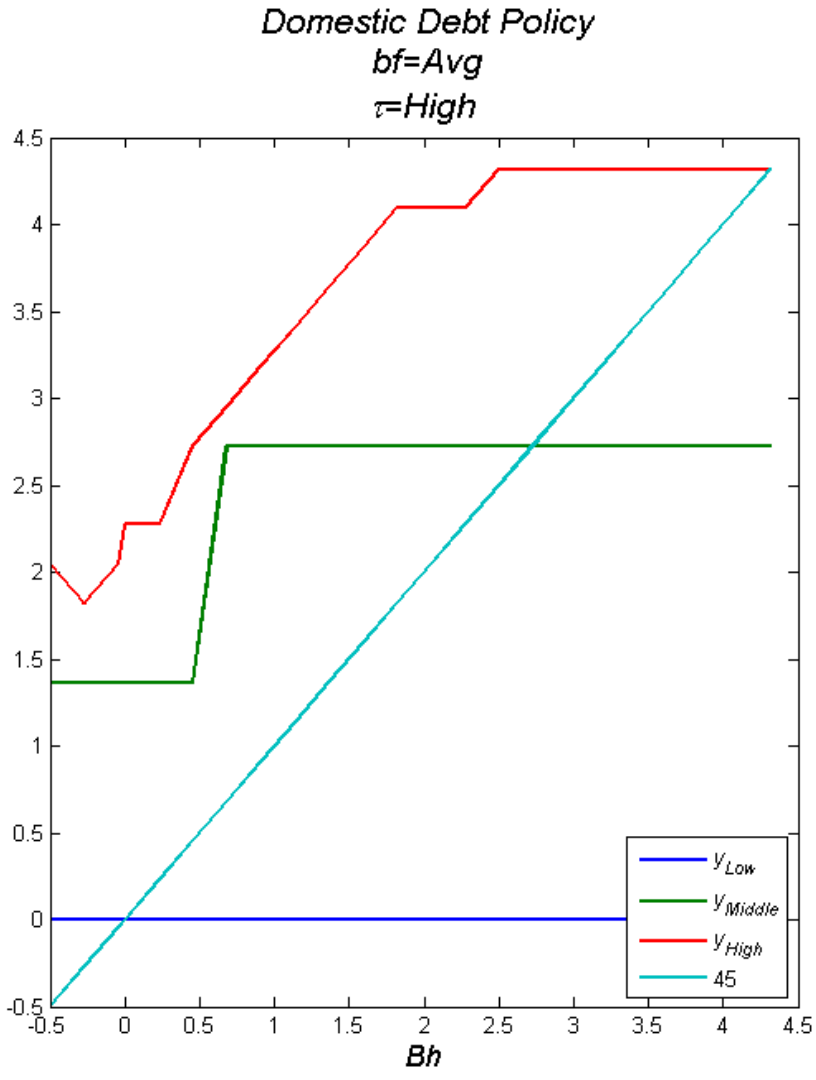
Debt Policies (I)



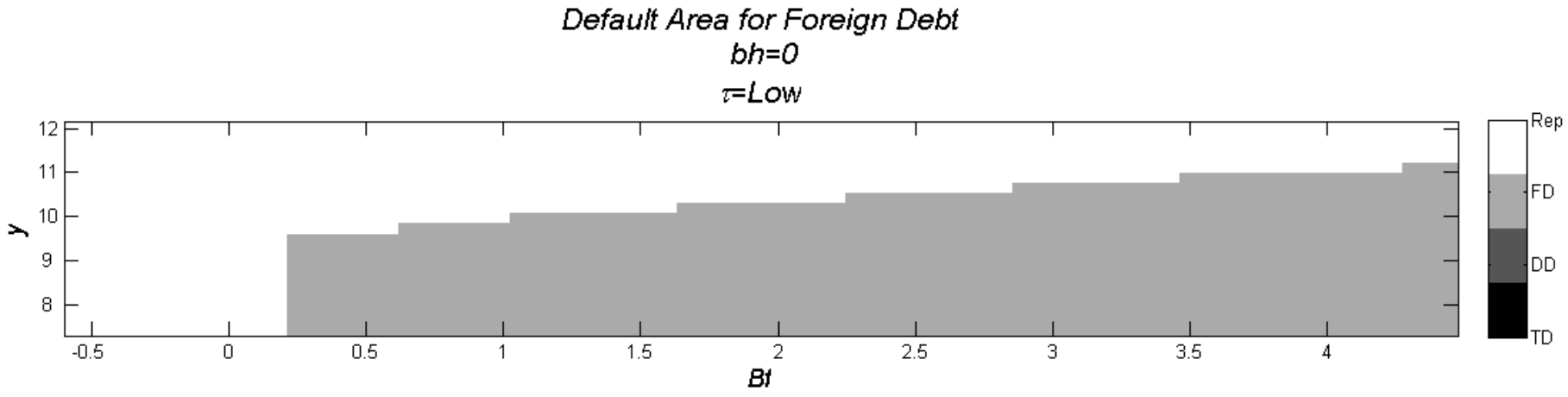


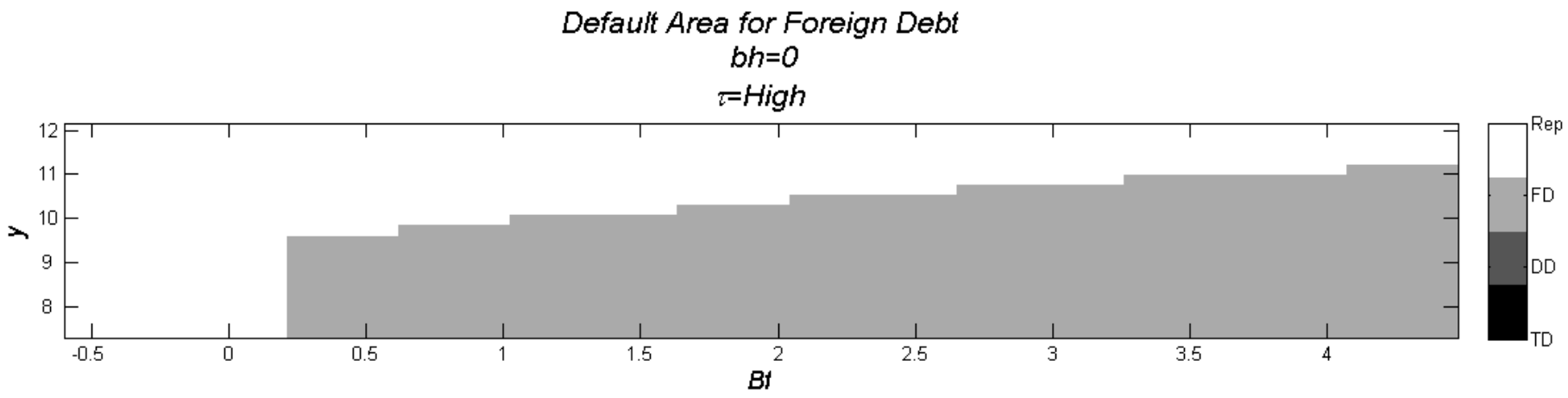
Debt policies (II)



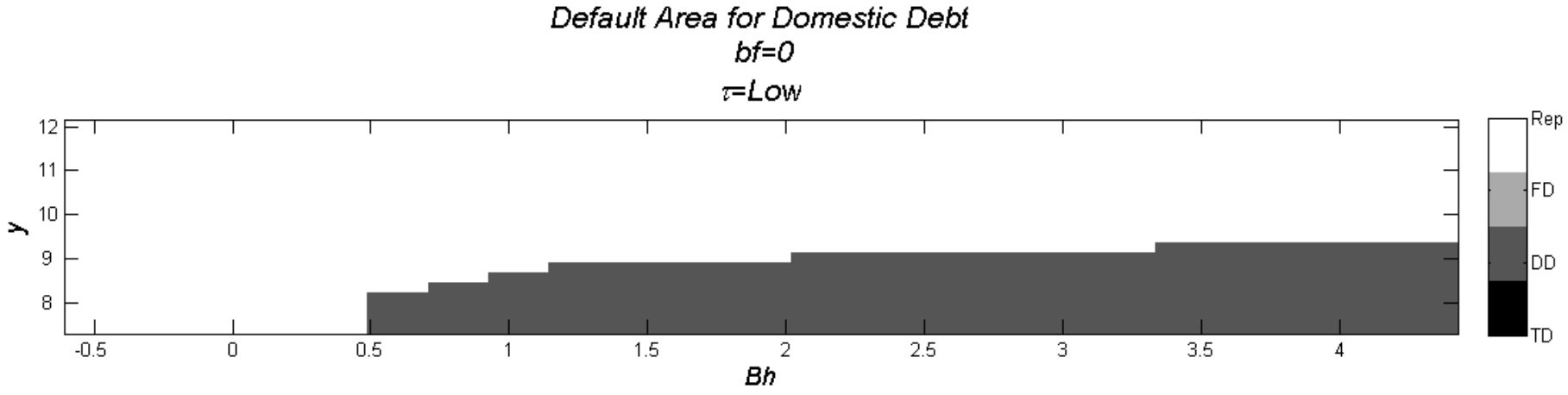


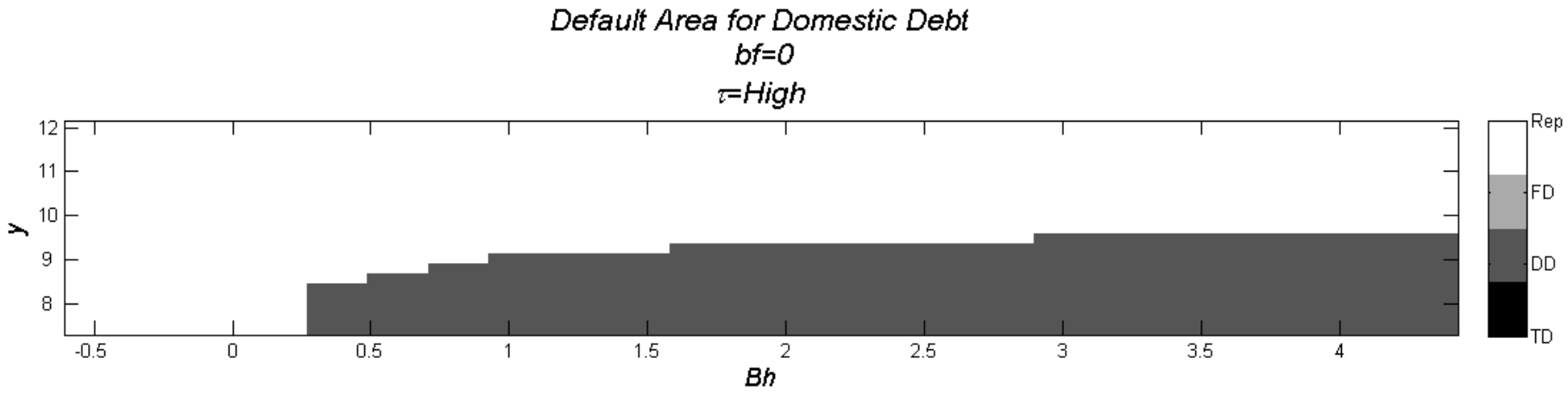
Default sets (I)





Default sets (II)





Business cycle statistics

Results from simulations

	Data (Argentina)	Model
Foreign default frequency	3.5%	3.5%
Domestic default frequency	2.5%	5.6%
Total default frequency	1.5%	0.3%
Avg. f-spread	12.67*pp*	8.9*pp*
Avg. d-spread	x	15.5*pp*
Foreign debt-to-GDP	17.22%	3.7%
Domestic debt-to-GDP	24.78%	13.7%
Consumption std. to output std.	1.098	1.00%

Secondary Markets and Haircuts

Setup (I)

Period 1:

- Markets are segmented
- Government issues b_h and b_f
- Households consume

Period 2:

- Nature selects $y = \{y_l, y_h\}$ and $\tau = \{\tau_l, \tau_h\}$
- Secondary markets open: investors trade b^{SM} at discout price q^{SM}
- SM close and government takes default decision d_h, d_f
- Households consume

Setup (II)

Assumptions:

- Nature selected y_l, τ_l
- Foreign debt is in default set $b_f - \bar{B}_f > 0 \qquad (b_f^{Lim})$
- Domestic debt is in repayment set $\bar{B}_h - b_h > 0 \qquad (b_h^{Lim})$
- Domestic investors want to buy less than foreign investors want to sell $b_f^{Lim} > b_h^{Lim}$

Strategies:

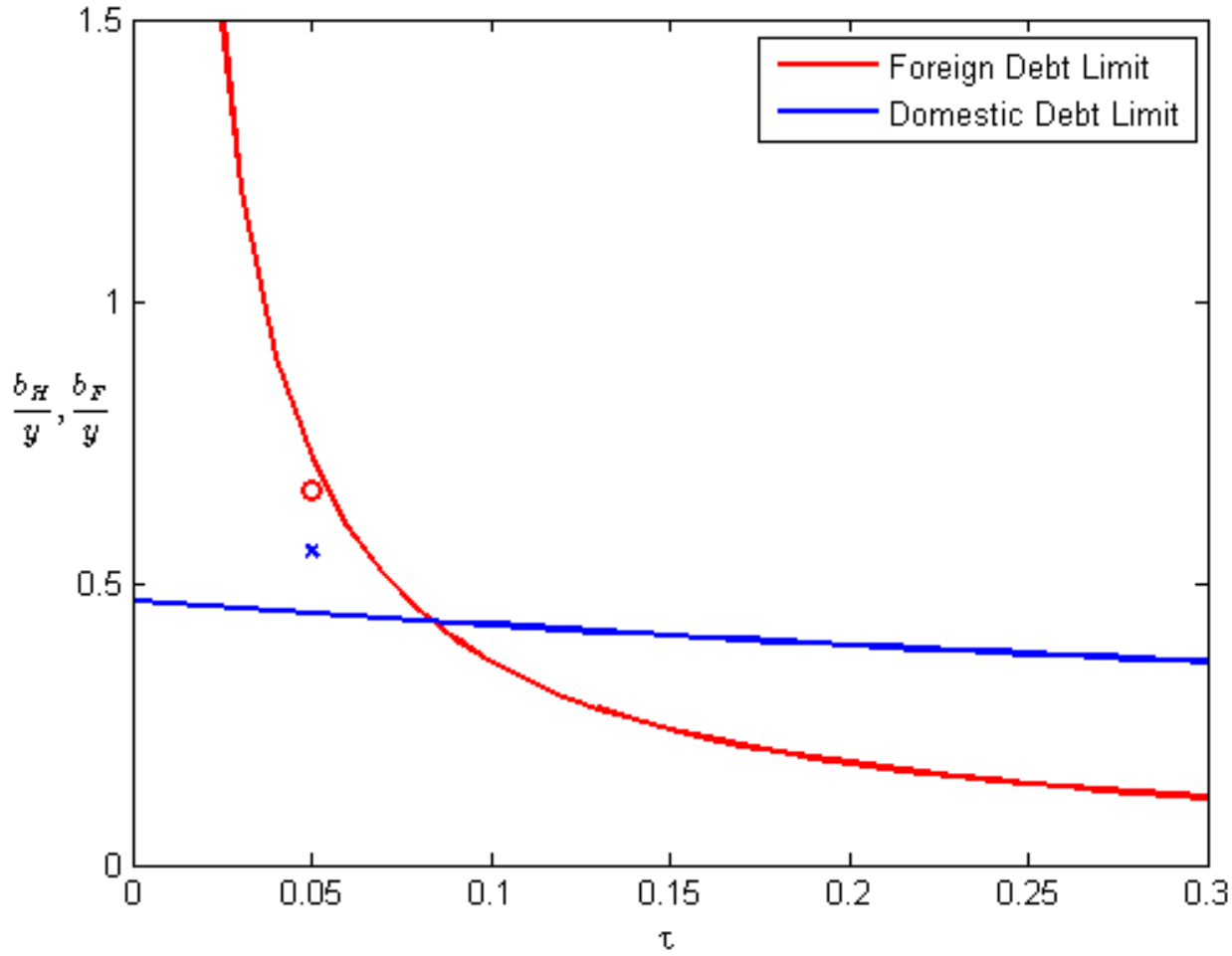
- Foreigners supply $b_S^{SM}(q^{SM})$
- Households demand $b_D^{SM}(q^{SM})$
- Government takes default decisions $\{d_h, d_f\} = \{0,1\}x\{0,1\}$
- Price q^{*SM} clears the market and is consistent with equilibrium outcome

We study Markov equilibria under two alternative assumptions:

- Infinitesimal investors
- ϵ-size investors

Secondary Markets

What happens if the debt can be retraded?



$$b_f^{Lim} > b_h^{Lim}$$

Secondary Markets

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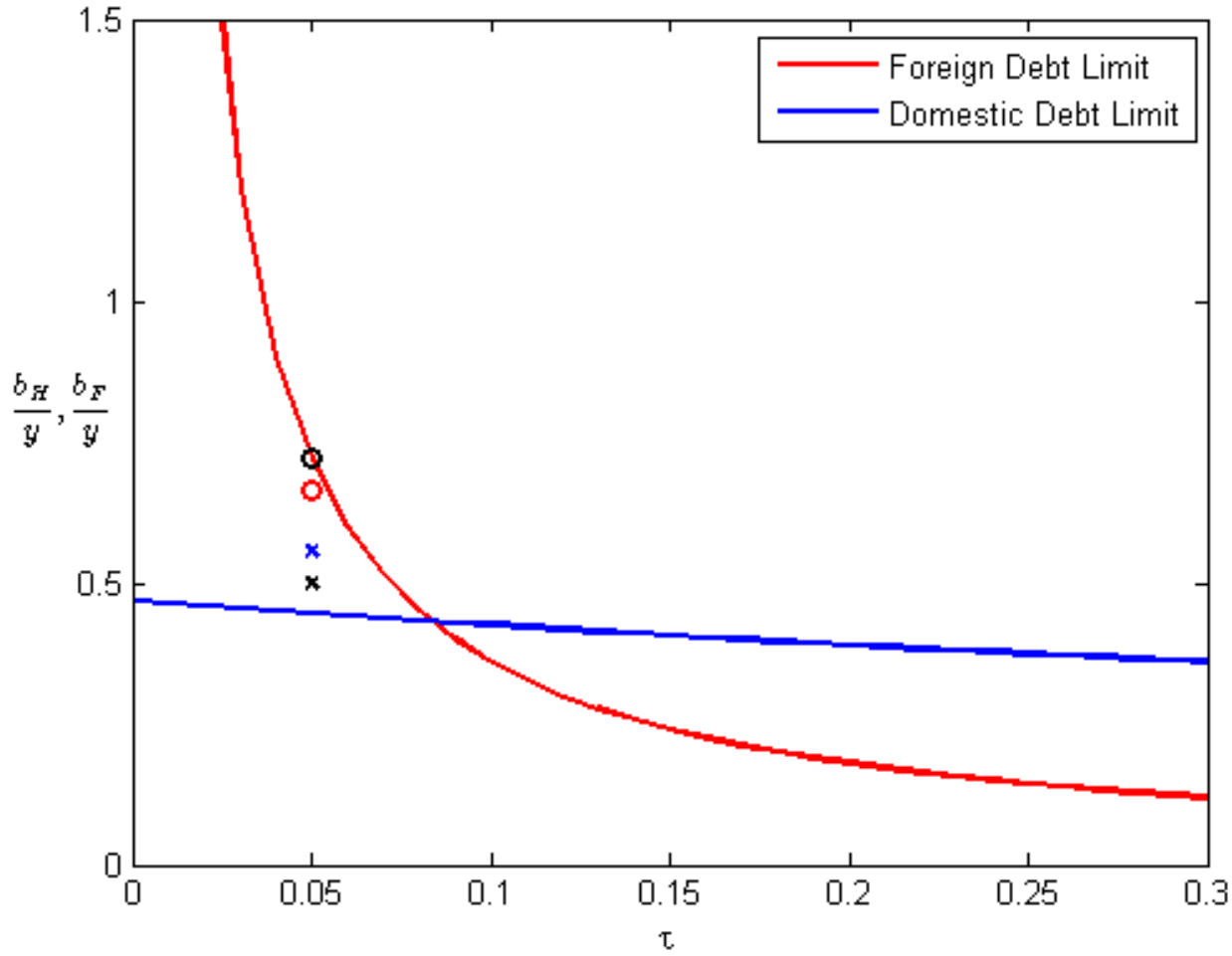

$$b_f^{Lim} > \mathbf{b_h^{Lim}}$$

Secondary Markets

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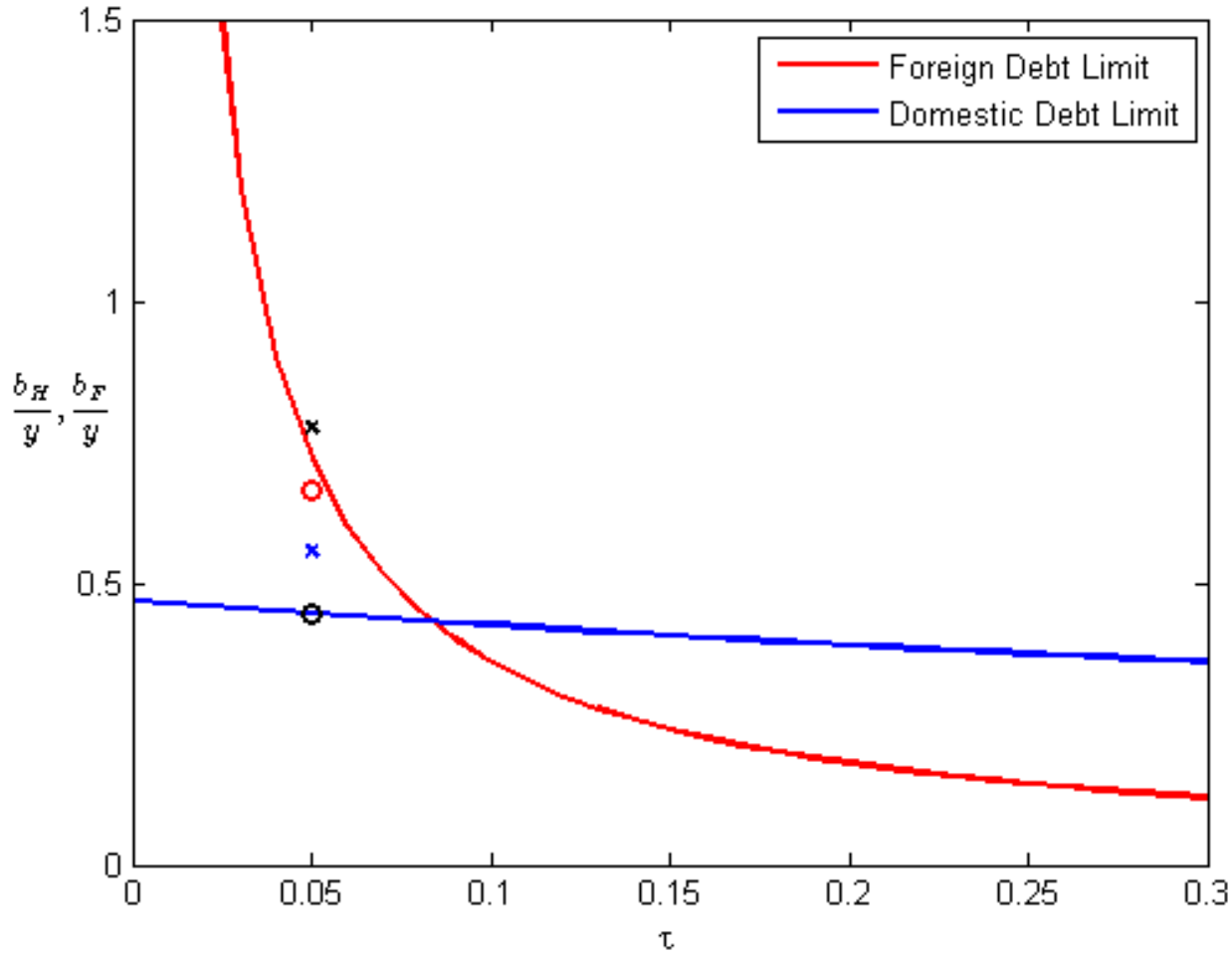

$$\mathbf{b_f^{Lim}} > b_h^{Lim}$$

Secondary Markets

Proposition 5: SM increase defaults

If both domestic and foreign investors are infinitesimal (cannot coordinate):

a. Nash equilibrium is indeterminate and degenerate

b. $b^{SM} \in (b_h^{Lim}, b_f^{Lim}) \qquad q^{SM} = 0$

c. $d_h = 1 \quad d_f = 1$

Secondary Markets

Proposition 6: SM switch default

If domestic investors are ϵ-size (can coordinate):

a. Nash equilibrium in pure strategies in indeterminate but yields unique allocation

b. $b^{SM} = b_h^{Lim} \qquad q^{SM} \in [0, 1]$

c. $d_h = 0, d_f = 1$

Proposition 7: SM destroy welfare

If foreign investors are ϵ-size and domestic investors are infinitesimal:

a. Nash equilibrium in pure strategies is unique and degenerate

b. $b^{SM} = b_f^{Lim} \qquad q^{SM} = 0$

c. $d_h = 1, d_f = 0$

Haircuts

Proposition 8: Haircut

If foreign investors are allowed free disposal and are ϵ-size (can coordinate):

a. Game is reduced to two players: foreign investors and government

b. Equilibrium is unique

c. b_f^{Lim} is free disposed

d. $d_h = 0, d_f = 0$

Conclusions

Conclusions:

1. Foreign debt to smooth output shocks, domestic debt to avoid costly taxation
2. Selective defaults due to different trade-offs and lack of commitment
3. Endogenous debt composition
4. Match business cycle and defaults data
5. Secondary markets and haircuts can solve sovereign debt problem depending on underlying conditions

Thank You

Thank you for your attention!