What is a sustainable public debt?

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What is sustainable public debt?

- Literally: *A sustainable debt is that which can be maintained at a certain rate or level*
  - A tautology unless that rate/level derives from a framework
- In macro literature:
  1. <u>With commitment</u>: debt consistent with solvency (IGBC) and/or a stationary equilibrium
  2. <u>Without commitment</u>: debt in equilibria with default risk
- Critical question in fiscal policy analysis
  - 2008-11, debt ratios rose by 31 (20) ppts. in U.S. (Europe)
  - Global market of local-currency gov. bonds was 1/2 of world's GDP in 2011 ($30 trillion, 6 times investment-grade external sov. debt)

Layout of the presentation

1. Historical perspective from U.S. data
2. Critical review of "classic" approach
3. *Empirical approach*: Bohn's Fiscal Reaction Function
4. *Structural approach*: Two-country DGE model with fiscal sector that matches actual tax elasticities
5. *Domestic default approach*: Model of optimal default driven by distributional incentives

- New applications to U.S. and cross-country data, and analysis of their implications

1. Historical perspective on U.S. public debt

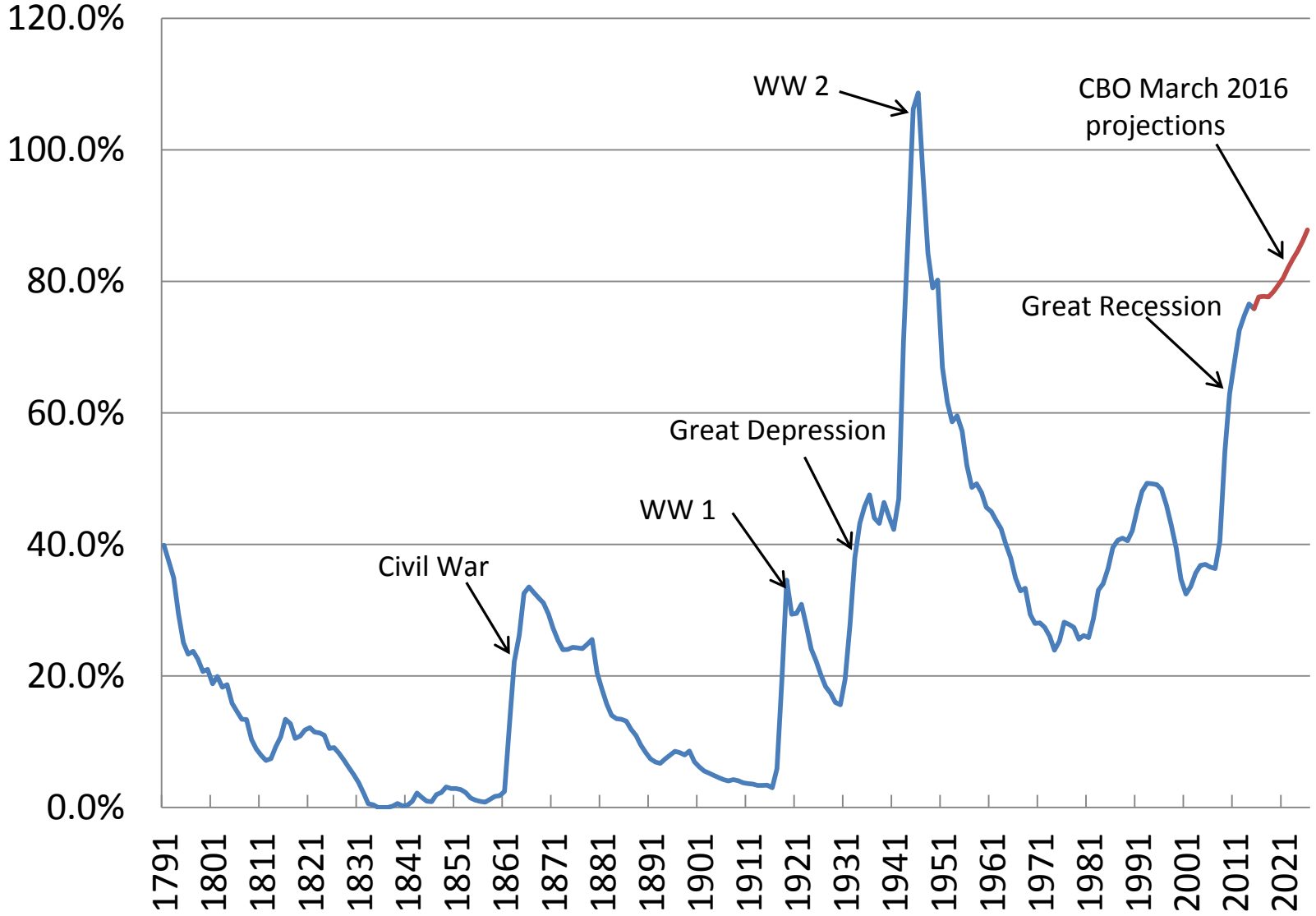
Debt crises in the United States

- Episodes in 95 percentile of annual increases in federal debt-GDP ratio since 1791 (ranked):
  1. WW 2
  2. WW 1
  3. Great Recession (but debt ratio is already 2nd highest)
  4. Civil War
  5. Great Depression

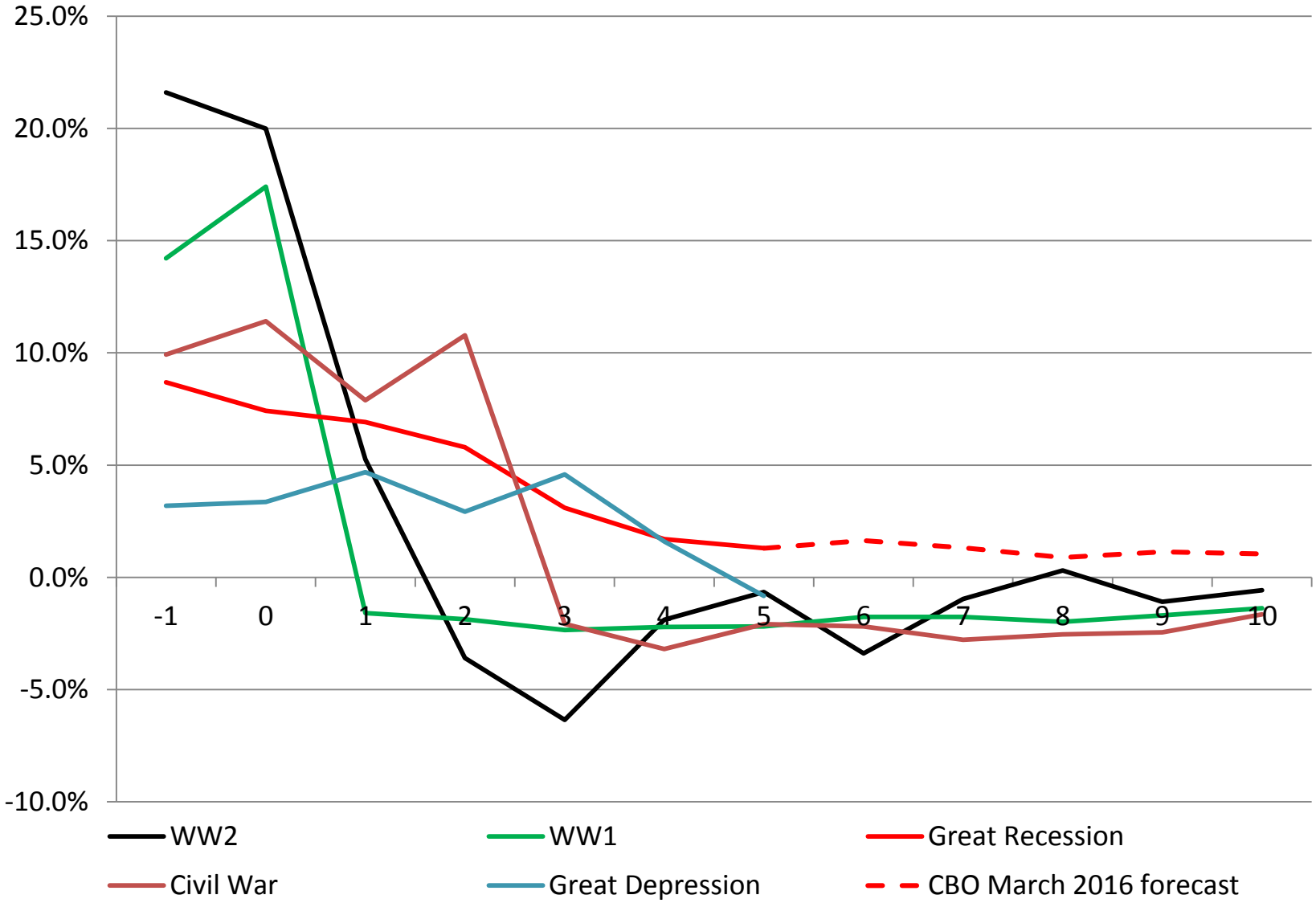
- GR episode is unique
  - Primary balance remains in deficit and is projected to remain in deficit at least through 2026! (CBO, 03/16)
  - In all other episodes, primary surpluses played a role in reducing debt

Public Debt Crises in U.S. History

(net federal debt-GDP ratio, 1791-2012 from Bohn (2013), 2013-2026 from CBO)



U.S. Primary Deficits after Debt Crises



What brought the debt down?

- Budget constraints in terms of GDP ratios:

$$b_t - b_{t-1} = def_t - \left(\frac{\gamma_t}{1+\gamma_t}\right) b_{t-1}$$

$$b_t - b_{t-1} = pr.def_t - \left(\frac{i_t - \gamma_t}{1+\gamma_t}\right) b_{t-1}$$

	Initial debt ratio	Final debt ratio	Change in debt ratio	Cumulated contribution of: Overall deficit	Growth effect	Primary deficit	Debt service	Net debt Service	annnualized rates: nominal growth	inflation	real growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
					I. Peak to Through						
a) 1792-1812	37.5%	7.2%	-30.3%	-7.2%	-23.1%	-25.2%	18.0%	-5.1%	5.8%	1.4%	4.3%
b) 1866-1916	33.5%	3.0%	-30.5%	-16.7%	-13.8%	-45.0%	28.3%	14.5%	3.3%	-0.6%	3.9%
c) 1919-1930	34.6%	15.6%	-19.0%	8.8%	-27.8%	-2.7%	11.6%	-16.3%	2.6%	0.1%	2.5%
d) 1946-1974	108.7%	23.9%	-84.8%	18.5%	-103.3%	-24.1%	42.6%	-60.7%	6.9%	3.3%	3.5%
e) 1994-2001	49.2%	32.5%	-16.7%	1.0%	-17.7%	-21.5%	22.4%	4.8%	5.6%	1.8%	3.7%
					II. Per-year averages						
a) 1792-1812			-1.5%	-0.4%	-1.2%	-1.3%	0.9%	-0.3%			
b) 1866-1916			-0.6%	-0.3%	-0.3%	-0.9%	0.6%	0.3%			
c) 1919-1930			-1.7%	0.8%	-2.5%	-0.2%	1.1%	-1.5%			
d) 1946-1974			-3.0%	0.7%	-3.7%	-0.9%	1.5%	-2.2%			
e) 1994-2001			-2.4%	0.1%	-2.5%	-3.1%	3.2%	0.7%			

2. Critical Review of Classic Approach

Generic government budget constraints

- Period GBC with Arrow gov. securities:

$$\sum_{s_{t+1}} Q_1(s_{t+1}|s_t) b_t(s_{t+1}|s^t) - b_{t-1}(s_t|s^{t-1}) = g(s_t) - \tau_t(s^t).$$

  – In GDP ratios and under perfect foresight:

$$b_t - (1+r_t) b_{t-1} = -pb_t \qquad r_t \equiv (1+i_t^r)/(1+\gamma_t) - 1$$

- NPG condition + arbitrage yields IGBC:

$$b_{t-1} = pb_t + \sum_{j=1}^{\infty} E_t[MRS(c_{t+j}, c_t) pb_{t+j}] \qquad pb_t \equiv \tau_t - g_t$$

Classic approach

- Proposed by Buiter (1985), Blanchard (1990), and widely used in policy institutions (IMF, 2015)
- At steady-state & under perfect foresight, GBC yields "Blanchard ratio" (debt-stabilizing *pb*):

$$b^{ss} = \frac{pb^{ss}}{r}$$

- First flaw: Disconnected from initial debt and IGBC
  - FRFs with different coefficients satisfy IGBC <u>for same initial debt</u> but attain different steady states, and can even go to infinity!

Classic approach (contn'd)

- Second flaw: Ignores uncertainty & asset markets
- Mendoza & Oviedo (06, 09): under incomplete markets, adding shocks + smoothing (or tolerable min. outlays) yields "*Natural Public Debt Limit*:"

$$b_t \leq NPDL \equiv \frac{\tau^{\min} - g^{\min}}{i^r - \gamma}$$

  - Blanchard ratio uses sample means (violates NPDL)
  - NPDL tighter for economies with more volatile revenues or less able to adjust outlays
  - Debt follows random walk with boundaries:

$$b_t = \max[NPDL, (1 + r_t)b_{t-1} - pb_t] \geq \bar{b}$$

3. Empirical Approach: Bohn's Fiscal Reaction Function

Bohn's Contributions

1. IGBC tests discounting at risk free rate are misspecified:

$$b_{t-1} = pb_t + \sum_{j=1}^{\infty} \left[\frac{E_t[pb_{t+j}]}{R_{t+j}} + cov_t\left(MRS(c_{t+j}, c_t), pb_{t+j}\right) \right]$$

2. IGBC holds if debt or outlays+interest are integrated of <u>any</u> finite order (no particular integration order needed!)

3. Linear FRF $pb_t = \mu_t + \rho b_{t-1} + \varepsilon_t,$ with $\rho > 0$ is <u>sufficient</u> for IGBC (debt is stationary if $\rho > r$, or diverges to infinity if $0 < \rho < r$ but is still sustainable!)

4. Empirical tests based on historical U.S. data 1791-2003 support linear FRF and some nonlinear variations

New FRF Estimates

- U.S. estimates (1791-2014) and cross-country panels (1951-2013) again pass sufficiency test
  - EMs have stronger response, less access to debt
- Structural break post-2008 (lower response, large residuals, large primary deficits)
- U.S. deficits have been much larger than out-of-sample pre-08 forecast
- FRFs with lower response coefficient satisfy IGBC at same initial debt, but with larger deficits & higher long-run debt

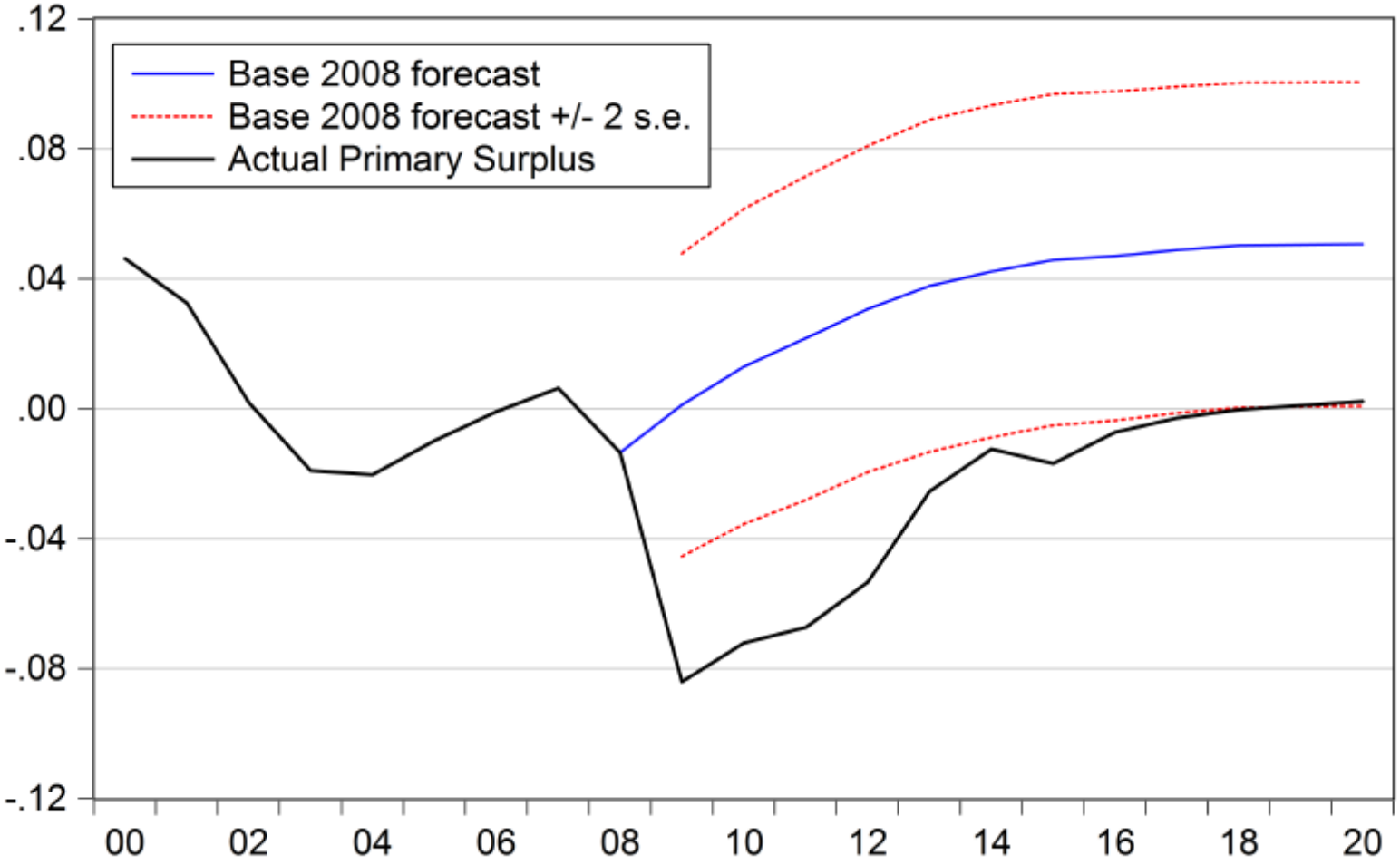
New FRF Estimates: U.S. 1792-2014

Model: Coefficient	Base model (1)	Asymmetric response (2)	AR(1) term (3)	Debt Squared (4)	Time trend (5)	Bohn's Sample (1793-2003) (6)	Pre-Recession (1793-2008) (7)
Constant	0.00648	0.00540	0.00974	0.00653	0.00601	0.00485	0.00470
	(0.004)	(0.003)*	(0.008)	(0.004)	(0.006)	(0.003)*	(0.003)
Initial debt d_t^*	0.07779	0.08689	0.10477	0.07715	0.07674	0.10498	0.10188
	(0.040)*	(0.030)***	(0.032)***	(0.038)*	(0.035)**	(0.023)***	(0.022)***
GDP gap	0.07404	0.07300	0.15330	0.07390	0.07490	0.07987	0.07407
	(0.078)	(0.079)	(0.043)***	(0.079)	(0.077)	(0.086)	(0.086)
Military Expenditure	-0.72302	-0.72001	-0.98955	-0.72320	-0.72462	-0.77835	-0.76857
	(0.133)***	(0.136)***	(0.110)***	(0.133)***	(0.135)***	(0.135)***	(0.135)***
$\max(0, d_t^* - \bar{d})$		-0.14487					
		(0.061)					
AR(1)			0.89154				
			(0.029)***				
$(d_t^* - \bar{d})^2$				0.00261			
				(0.044)			
Time trend					6.89E-06		
					(5.9E-05)		
s.e	0.0239	0.0240	0.198	0.0120	0.0240	0.0210	0.0209
Adj. R-squared:	0.606	0.605	0.901	0.614	0.605	0.695	0688
Observations:	223	223	222	223	223	213	217

Note: HAC standard errors shown in parenthesis, 2-lag window prewhitening. "*", "**", "***" denote that the corresponding coefficient is statistically significant at the 90, 95 and 99 percent confidence levels. Output gap is percent deviation from Hodrick-Prescott trend. Military expenditure includes all Department of Defense and Department of Veterans Affairs outlays.

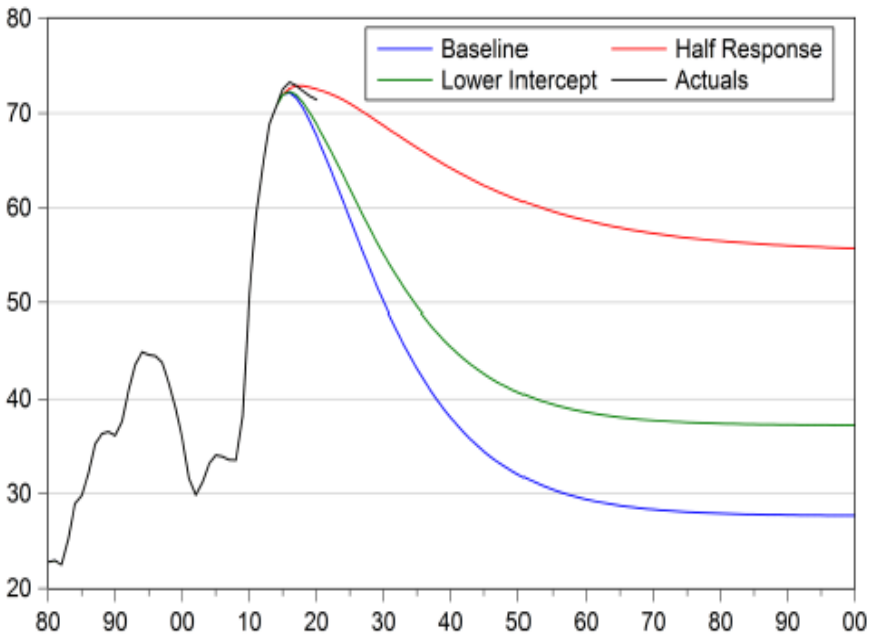
U.S. Primary Balance Post-2008 Forecast

(2009-2020 forecast from 1791-2008 FRF regression)

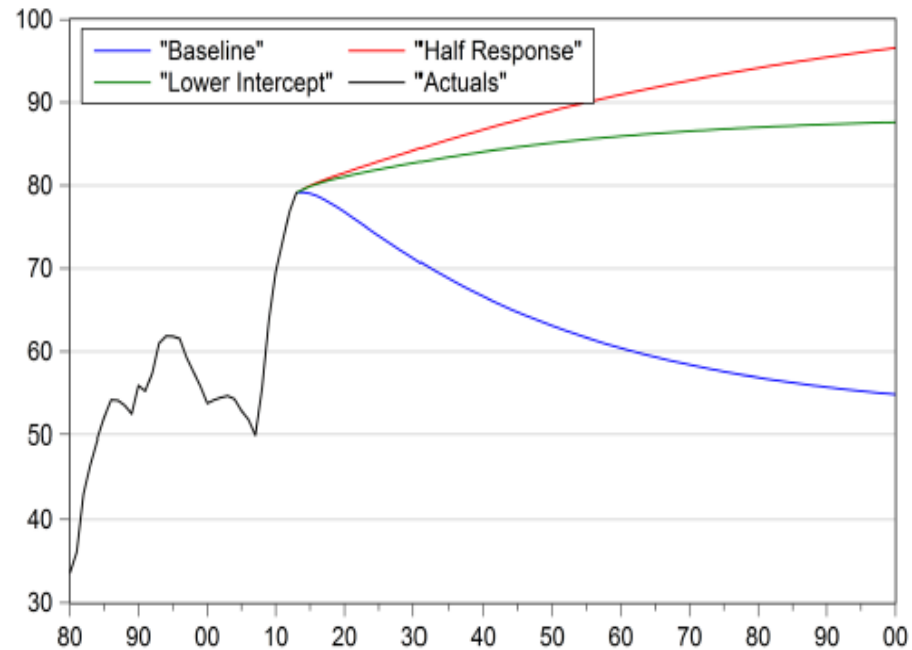


Out-of-sample forecast uses actual values for the independent variables for 2009-2014 and 2016 President's Budget for 2015-2020

Debt Projections: Alternative FRFs



(a) US debt to GDP



(b) Europe debt to GDP

Note: For the US: Model (3) in table 1 is used in conjunction with estimated AR(2) processes for the output gap and military expenditure, plus the government budget constraint. For Europe: Model (5) in table 2 is used in conjunction with estimated AR(1) processes for the output gap and government consumption gap in each country, and a simple average among advanced European countries is taken.

4. Structural Approach: Two-Country Dynamic General Equilibrium Model

Why use a structural approach?

- FRFs with different parameters satisfy IGBC for same initial debt, but macro dynamics and welfare differ and FRFs can't compare them
- Use calibrated variant of workhorse two-country Neoclassical model to compare fiscal adjustment policies in response to an increase in initial debt
- Match observed tax elasticities by introducing utilization and limited depreciation tax allowance

Model highlights

- Deterministic setup with exogenous long-run growth driven by labor-augmenting technological change
- Fiscal sector includes taxes on capital, labor and consumption, gov. purchases, transfers and debt
- Utilization choice & limited tax allowance for depreciation
- Trade in goods and bonds (residence-based taxation)
- Capital immobile across countries, but trade in bonds arbitrages post-tax returns & induces capital reallocation
- Unilateral tax changes have cross-country externalities (relative prices, wealth distribution, tax revenues)

Fiscal sector

- Gov. purchases and transfers are exogenous and kept constant at initial steady-state levels
- GBC:

$$d_t - (1+\gamma) q_t^g d_{t+1} = pb_t$$

$$\equiv \tau_C c_t + \tau_L w_t l_t + \tau_K (r_t m_t - \theta \bar{\delta}) k_t - (g_t + e_t)$$

- IGBC:

$$\frac{d_0}{y_{-1}} = \psi_0 \left[\frac{pb_0}{y_0} + \sum_{t=1}^{\infty} \left(\left[\prod_{i=0}^{t-1} \upsilon_i \right] \frac{pb_t}{y_t} \right) \right]$$

$$\upsilon_i \equiv (1+\gamma) \psi_i q_i^g,$$

$$\psi_i \equiv y_{i+1} / y_i$$

  – Dynamic Laffer curves (DLCs) plot change in PDV of *pb/y* (i.e. in sustainable debt) as a tax rate changes

Tax distortions and externalities

- Asset markets arbitrage (ignoring capital adj. costs):

$$\frac{(1+\gamma)u_1(c_t, 1-l_t)}{\tilde{\beta}u_1(c_{t+1}, 1-l_{t+1})} = (1-\tau_K)F_1(m_{t+1}k_{t+1}, l_{t+1})m_{t+1} + 1 - \delta(m_{t+1}) + \tau_K\theta\bar{\delta}$$

$$= \frac{1}{q_t} = \frac{1}{q_t^g}$$

$$= (1-\tau_K^*)F_1(m_{t+1}^*k_{t+1}^*, l_{t+1}^*)m_{t+1}^* + 1 - \delta(m_{t+1}^*) + \tau_K^*\theta\bar{\delta} = \frac{(1+\gamma)u_1(c_t^*, 1-l_t^*)}{\tilde{\beta}u_1(c_{t+1}^*, 1-l_{t+1}^*)}$$

- Labor market:

$$\frac{u_2(c_t, 1-l_t)}{u_1(c_t, 1-l_t)} = \frac{1-\tau_L}{1+\tau_C}F_2(k_t, l_t) \qquad (1-\tau_W) \equiv (1-\tau_L)/(1+\tau_C)$$

- Capacity utilization :

$$F_1(m_tk_t, l_t) = \frac{1+\Phi_t}{1-\tau_K}\delta'(m_t),$$

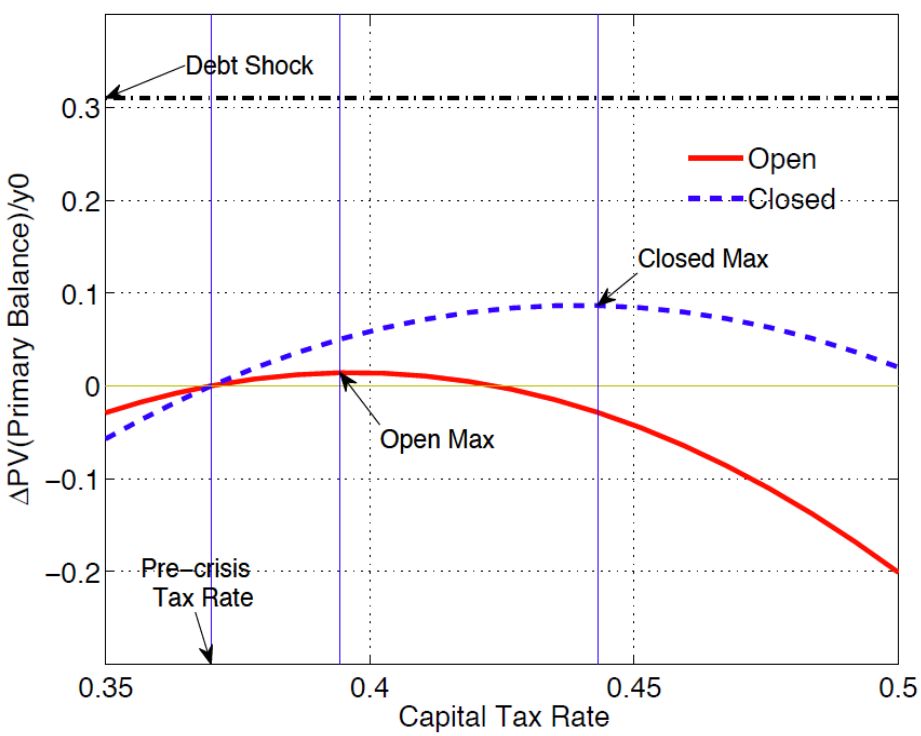
Calibration: Fiscal Heterogeneity

	GDP-weighted	
	EU15	US
(a) Macro Aggregates		
τ_C	0.17	0.04
τ_L	0.41	0.27
τ_K	0.32	0.37
c/y	0.57	0.68
x/y	0.21	0.21
g/y	0.21	0.16
tb/y	0.00	−0.05
Rev$/y$	0.45	0.32
Total Exp$/y$	0.47	0.39
(b) Debt Shocks		
d_{2007}/y_{2007}	0.38	0.43
d_{2011}/y_{2011}	0.58	0.74
$\Delta d/y$	0.20	0.31

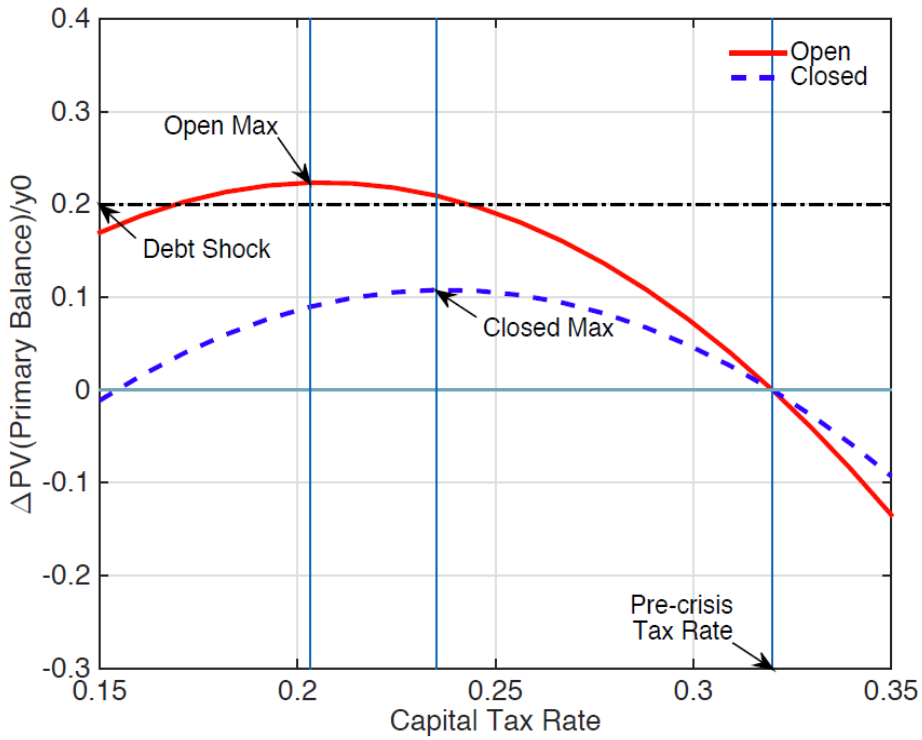
Main findings

- Capital taxes:
  1. Large externalities (strategic incentives)
  2. US: debt *not* sustainable (DLC max below required level)
  3. EU15: inefficient side of DLC (tax cut makes debt sustainable via external effects--closed-economy DLC also peaks below required level)
  4. Without utilization and limited allowance short-run tax elasticity has wrong sign and DLC is linearly increasing
- Labor taxes:
  1. Negligible externalities
  2. US low initial taxes yield DLCs that sustain higher debt
  3. EU15: DLCs (closed or open) peak below required level

Capital Tax Dynamic Laffer Curves



(a) US



(b) EU15

Effects of Using Maximum US Capital Tax Rate

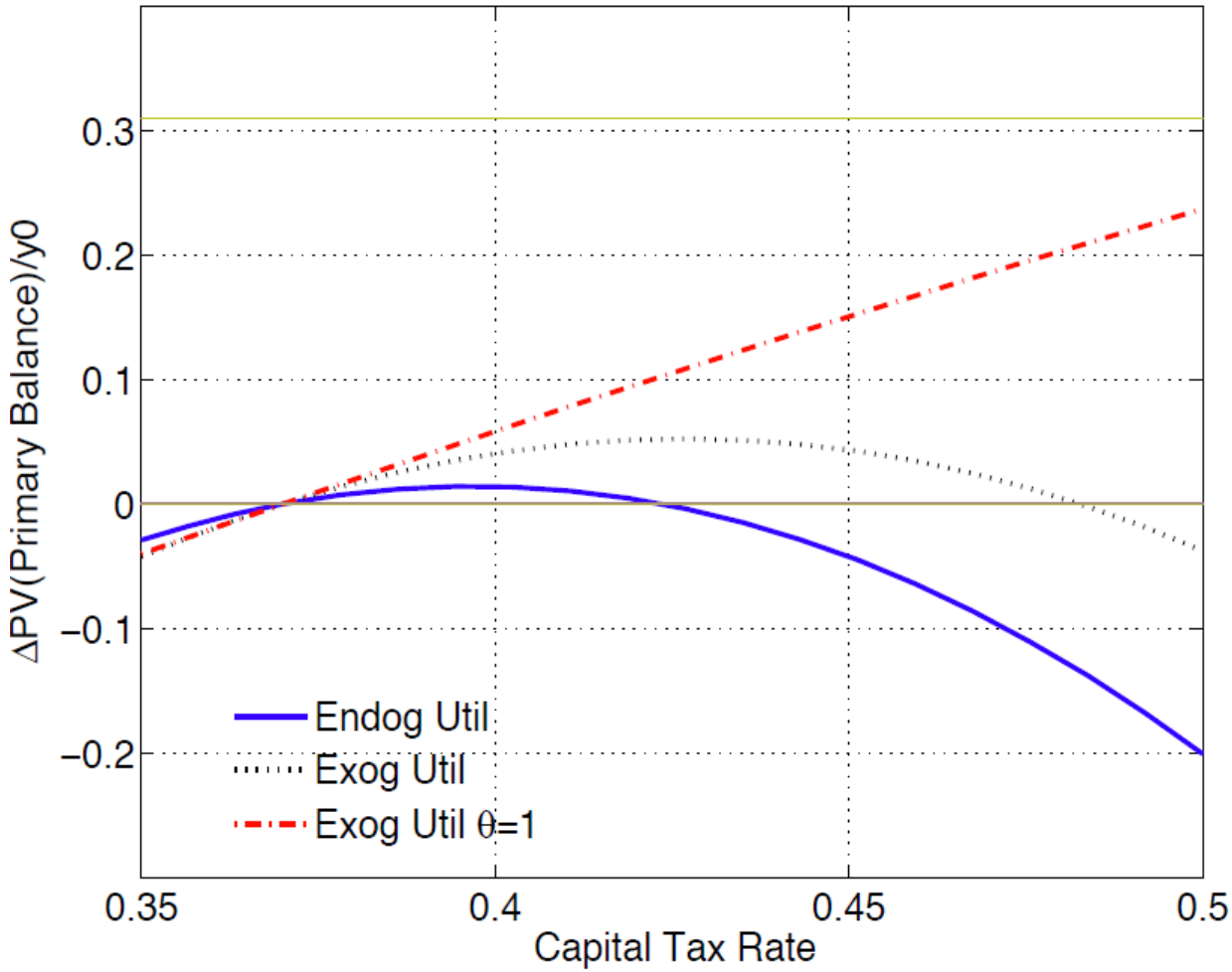
	Open Economy			
	Home		Foreign	
Tax rates	Old	New	Old	New
τ_K	0.37	0.40	0.32	0.32
τ_C	0.04	0.04	0.17	0.17
τ_L	0.27	0.27	0.41	0.40
ΔPV(Primary Bal.)/y_0		0.014		0.00
Welfare Impact		−2.19		0.74
Δy_{ss}		−3.87		1.25

Note: Capital tax increase to maximum point of open-economy Laffer curve. Fore neutrality by lowering labor tax.

Capital Tax Base Elasticities: Models v. Data

	Elasticity	y_1	l_1	m_1
Empirical estimates	[0.1, 0.5]			
Model Implications for the U.S.				
exog. utilization & $\theta = 1$	-0.09	0.04%	0.011	
exog. utilization & $\theta = 0.2$	-0.09	0.08%	0.028	
endog. utilization & $\theta = 0.2$	0.29	-0.15%	0.010	-0.471

U.S. Capital Tax DLCs: Alternative Models



(a) US

5. Domestic Default Approach: Default as Optimal Redistributive Policy

Why a domestic default approach?

- Previous two approaches cast doubt on chances of restoring fiscal solvency via conventional tools
- European crisis + historical evidence (Reinhart & Rogoff (11), Hall & Sargent (14)) raise possibility of <u>domestic</u> defaults
  - A "forgotten history" (R&R) until recently (D'Erasmo & Mendoza (2013,14), Dovis et al. (2014), …)
- Remove commitment: Distributional incentives lead to default unless costs are sufficiently high or gov. favors bond holders
  - Solvency is not enough to make debt sustainable!

A model of optimal domestic default

(D'Erasmo & Mendoza, JEEA 2016)

- Two-period model with two types of risk-averse agents (*L*, *H*), with fraction γ of L-types ($b_0^L < b_0^H$)
- Gov. collects lump-sum taxes τ, faces stochastic *g*, issues bonds B (*g* and default are non-insurable aggregate risks)
- Default is costly as a fraction $\phi(g)$ of income that varies with realization of *g* (a'la Arellano (2008))

$$\phi(g_1) \geq 0, \text{ with } \phi'(g_1) \leq 0 \text{ for } \; g_1 \leq \overline{g}_1, \; \phi'(g_1) = 0 \text{ otherwise}$$

- Gov. attains 2nd-best deviation from equal mg. utilities by redistributing via debt & default

Agents' Optimization Problem

Payoff function for i=*L,H* :

$$v^i(B_1,\gamma) = \max_{b_1^i} \Big\{ u(y + b_0^i - q_0 b_1^i - \tau_0) +$$

$$\beta E_{g_1}\Big[(1 - d_1(B_1, g_1, \gamma))u(y + b_1^i - \tau_1^{d_1=0}) + d_1(B_1, g_1, \gamma)u(y(1 - \phi(g_1)) - \tau_1^{d_1=1})\Big]\Big\}$$

$$\text{subject to } b_1^i \geq 0.$$

with initial bond holdings given by initial wealth distribution and bond market clearing:

$$b_0^H = \frac{B_0 - \gamma b_0^L}{1-\gamma} \geq b_0^L \geq 0$$

Government

Budget constraints

$$\tau_0 = g_0 + B_0 - q_0 B_1$$

$$\tau_1^{d_1=0} = g_1 + B_1 \qquad \tau_1^{d_1=1} = g_1$$

Default optimization problem in 2nd period (utilitarian SWF):

$$\max_{d\in\{0,1\}} \left\{ W_1^{d=0}(B_1, g_1, \gamma), W_1^{d=1}(g_1, \gamma) \right\}$$

$$W_1^{d=0}(B_1, g_1, \gamma) = \gamma u(y - g_1 + b_1^L - B_1) + (1-\gamma) u(y - g_1 + b_1^H - B_1)$$

$$W_1^{d=1}(g_1, \gamma) = u(y(1 - \phi(g_1)) - g_1)$$

Debt issuance optimization problem in 1st period:

$$W_0(\gamma) = \max_{B_1} \left\{ \gamma v^L(B_1, \gamma) + (1-\gamma) v^H(B_1, \gamma) \right\}$$

Default Decision in 2nd Period

- Assume bond demand choices given by:

$$b_1^L = B_1 - \epsilon \text{ and } b_1^H(\gamma) = B_1 + \frac{\gamma}{1-\gamma}\epsilon$$

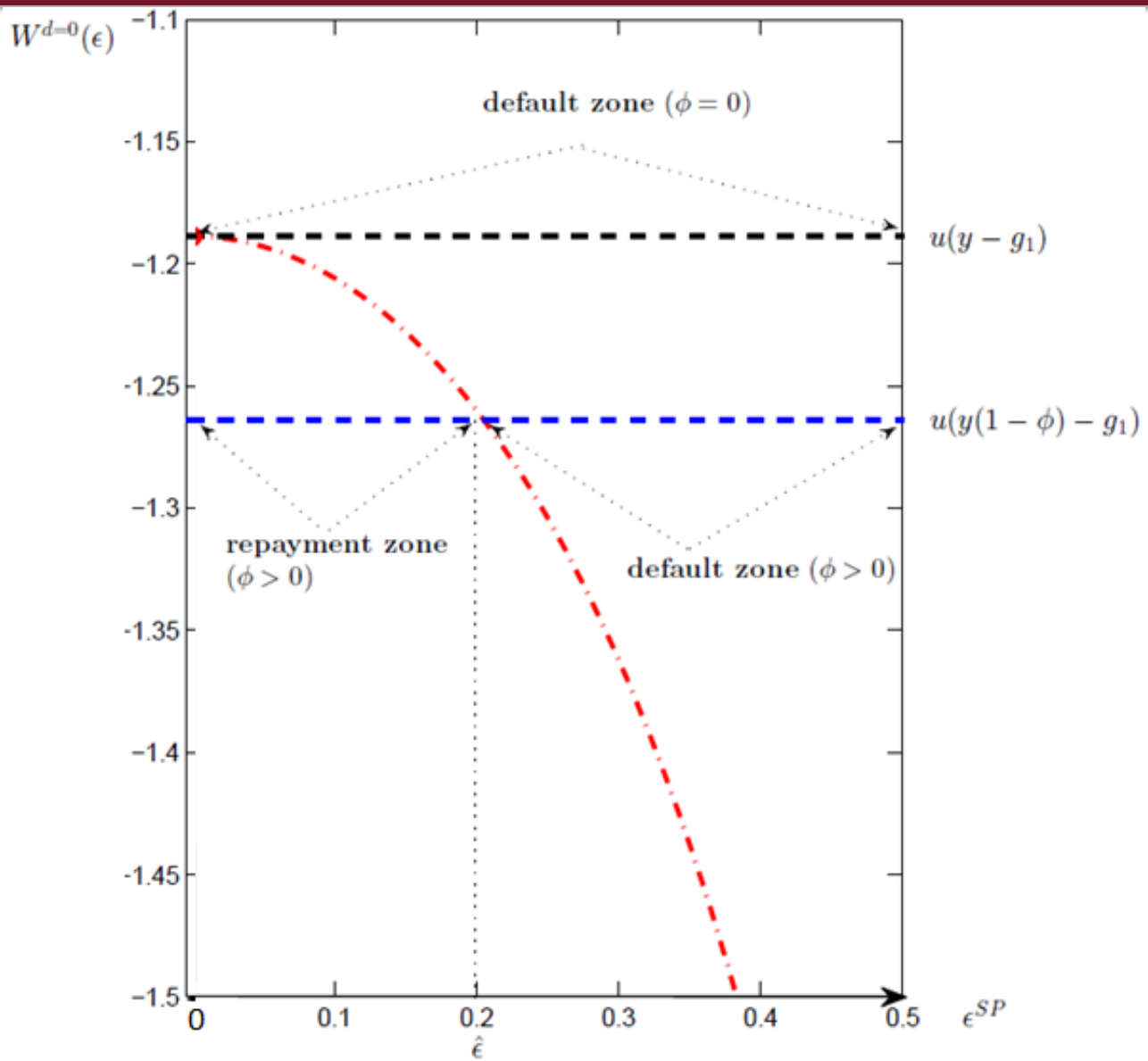
- Socially optimal allocations (under repayment):

$$u'\left(y - g_1 + \frac{\gamma}{1-\gamma}\epsilon^{SP}\right) = u'\left(y - g_1 - \epsilon^{SP}\right) \Longleftrightarrow \epsilon^{SP} = 0$$

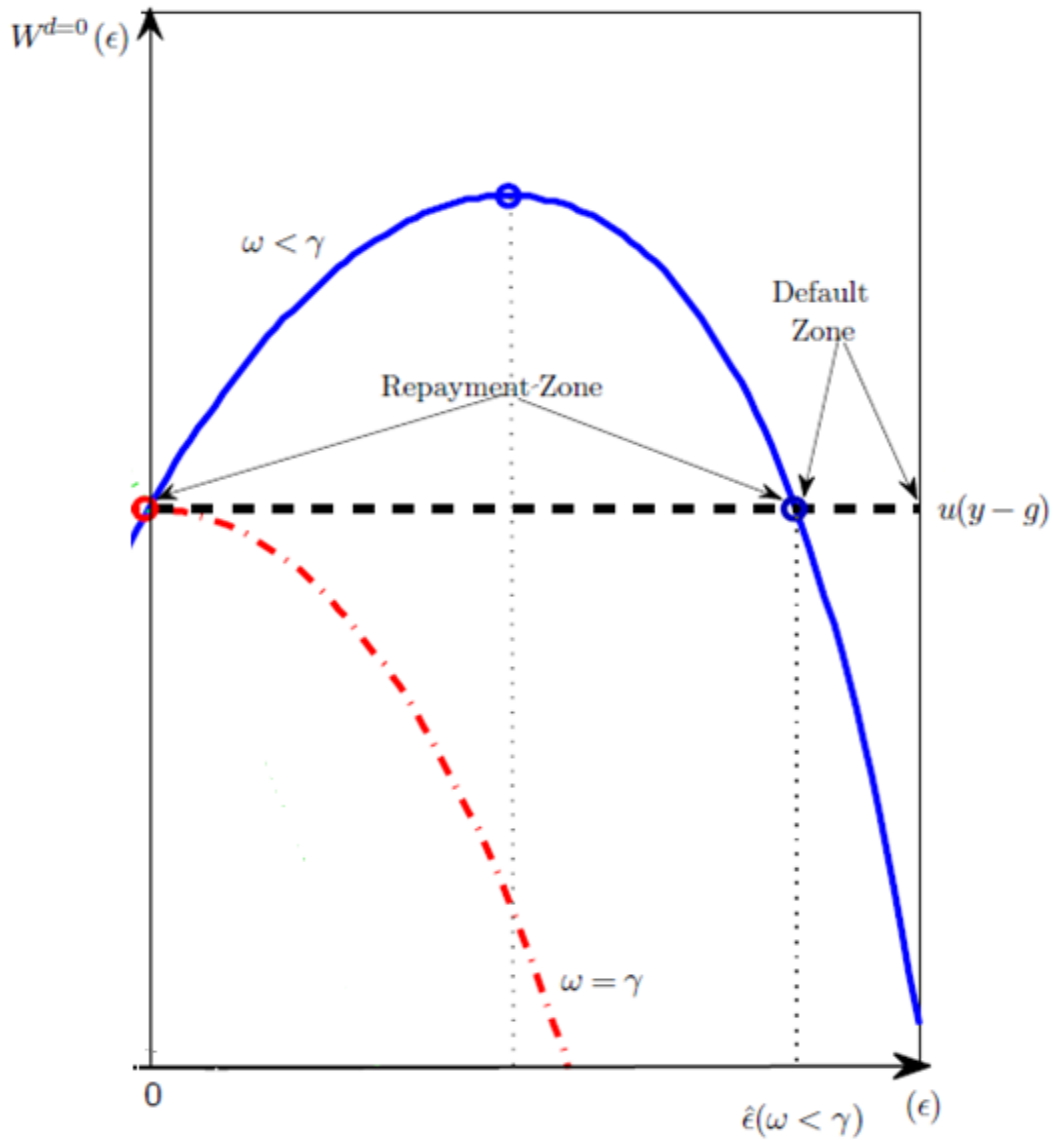
  – Zero consumption dispersion is first best

- If default is costless, it is always optimal (attains 1st best) and debt cannot be sustained.
  – Cost makes default suboptimal (for some bond demand choices dispersion is smaller with repayment)
  – Cost can be endogenized (liquidity, self-insurance) or replaced with gov. bias favoring bond holders

Default choice with & without default costs



Default choice with government bias



Debt Issuance Decision in 1st Period

- Selling debt reduces dispersion at t=0, but increases it at t=1 under repayment:

$$
\begin{aligned}
c_0^H - c_0^L &= \frac{1}{1-\gamma}\left[B_0 - \boxed{q(B_1,\gamma)B_1}\right] \\
c_1^{H,d=0} - c_1^{L,d=0} &= \frac{1}{1-\gamma}B_1 \\
c_1^{H,d=1} - c_1^{L,d=1} &= 0.
\end{aligned}
$$

- Gov. internalizes how the gain of issuing debt is hampered by default risk, which lowers bond prices (debt Laffer curve).

Debt Issuance Optimality Condition

- Without default, some dispersion is optimal (debt helps relax L-types borrowing constraint)

$$u'(c_0^H) = u'(c_0^L) + \frac{\eta}{q(B_1,\gamma)\gamma}\left\{\gamma\mu^L\right\}$$

$$\mu^L \equiv q(B_1,\gamma)u'(c_0^L) - \beta E_{g_1}\left[(1-d^1)u'(c_1^L)\right] > 0.$$

- With default risk, more dispersion at t=0 is traded off for possibly zero at t=1 in default states

$$u'(c_0^H) = u'(c_0^L) + \frac{\eta}{q(B_1,\gamma)\gamma}\left\{\beta E_{g_1}\left[\Delta d \Delta W_1\right] + \gamma\mu^L\right\}$$

$$\Delta d \equiv d(B_1+\delta, g_1, \gamma) - d(B_1, g_1, \gamma) \geq 0, \quad \text{for } \delta > 0 \text{ small},$$

$$\Delta W_1 \equiv W_1^{d=1}(g_1,\gamma) - W_1^{d=0}(B_1, g_1, \gamma) \geq 0,$$

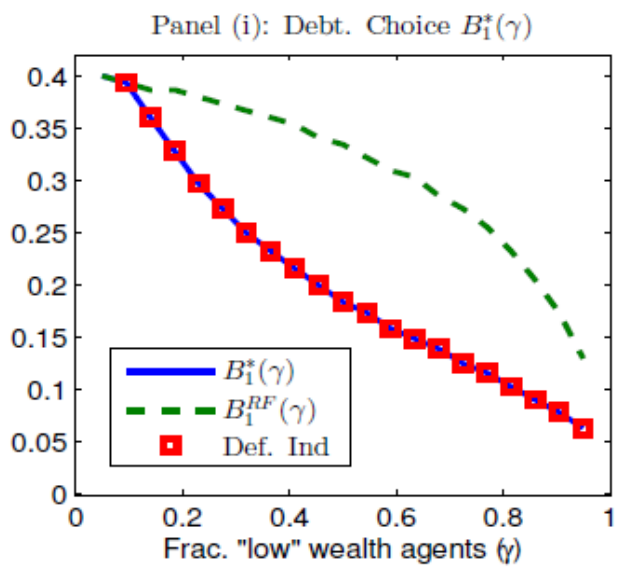
Calibration to European Data

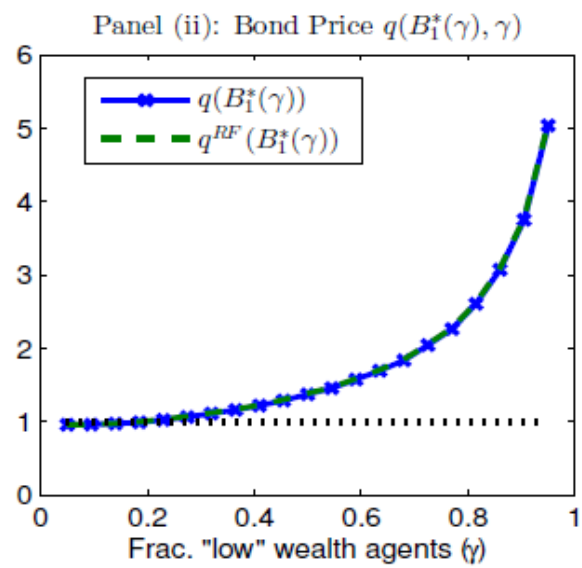
Parameter		Value
Discount Factor	β	0.96
Risk Aversion	σ	1.00
Avg. Income	y	0.79
Low household wealth	b_0^L	0.00
Avg. Gov. Consumption	μ_g	0.18
Autocorrel. G	ρ_g	0.88
Std Dev Error	σ_g	0.017
Initial Gov. Debt	B_0	0.79
Output Cost Default	ϕ_0	0.02

Note: Government expenditures, income and debt values are derived using data from France, Germany, Greece, Ireland, Italy, Spain and Portugal.

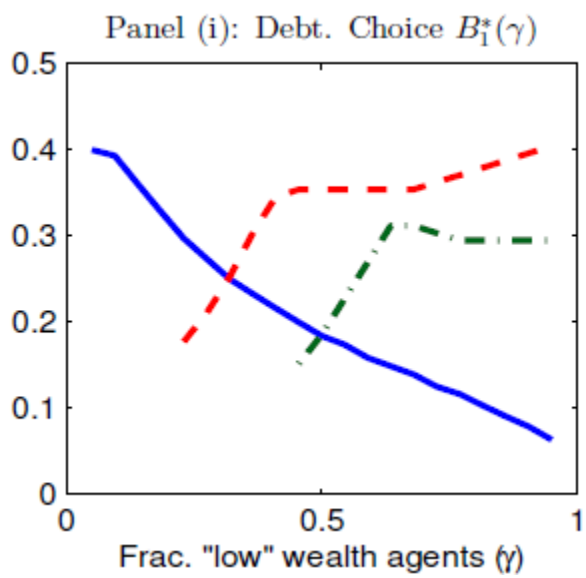
Equilibria as Fraction of Non-debt-holders Rises

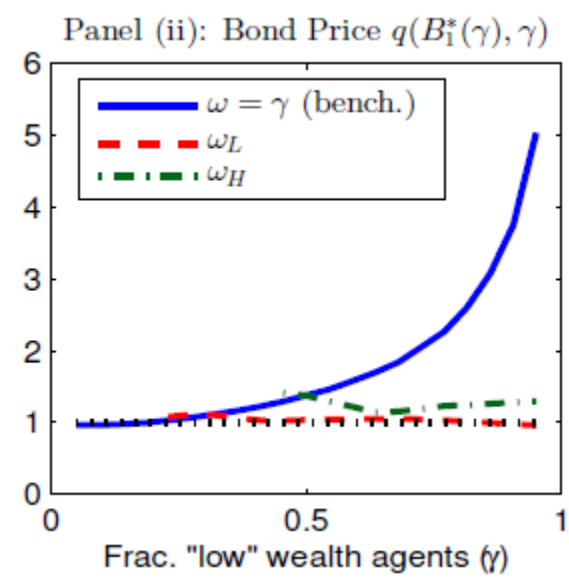
Utilitarian government





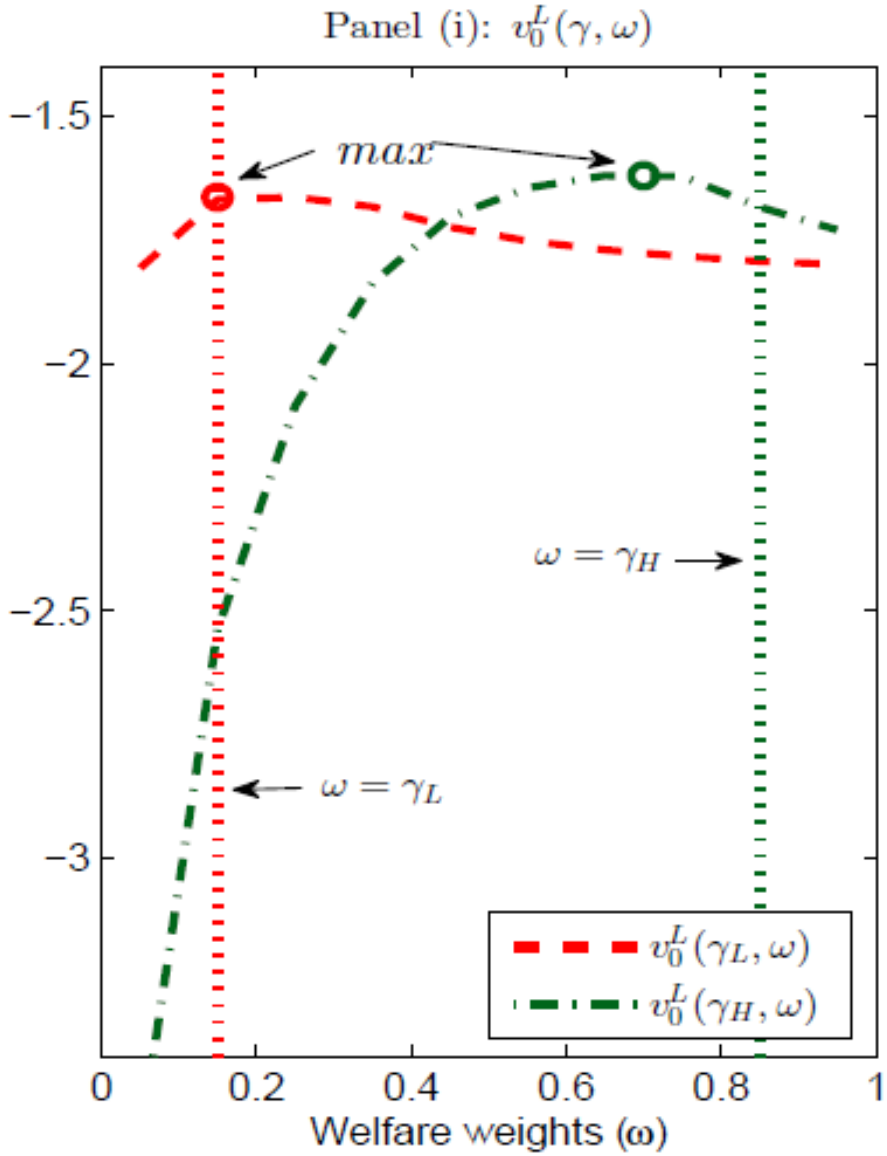
Biased government





Non-bond-holders may prefer bias!

(if ownership is sufficiently concentrated)



Conclusions

- Three approaches to examine sustainable debt paint a bleak picture of fiscal prospects:

  1. FRFs structural break post-2008, primary deficits much larger than predicted, larger than in previous crises

  2. Capital tax DLCs peak well below required increase to offset higher debt (except if EU exploits externalities)

  3. Domestic default is a real possibility (default costs or gov. bias make debt exposed to default risk due to distributional incentives sustainable)

  4. Economies with concentrated debt ownership may elect biased governments that sustain high debt at low spreads and default probs. (but default happens!).