Sovereign credit ratings in the European Union: a model-based fiscal analysis

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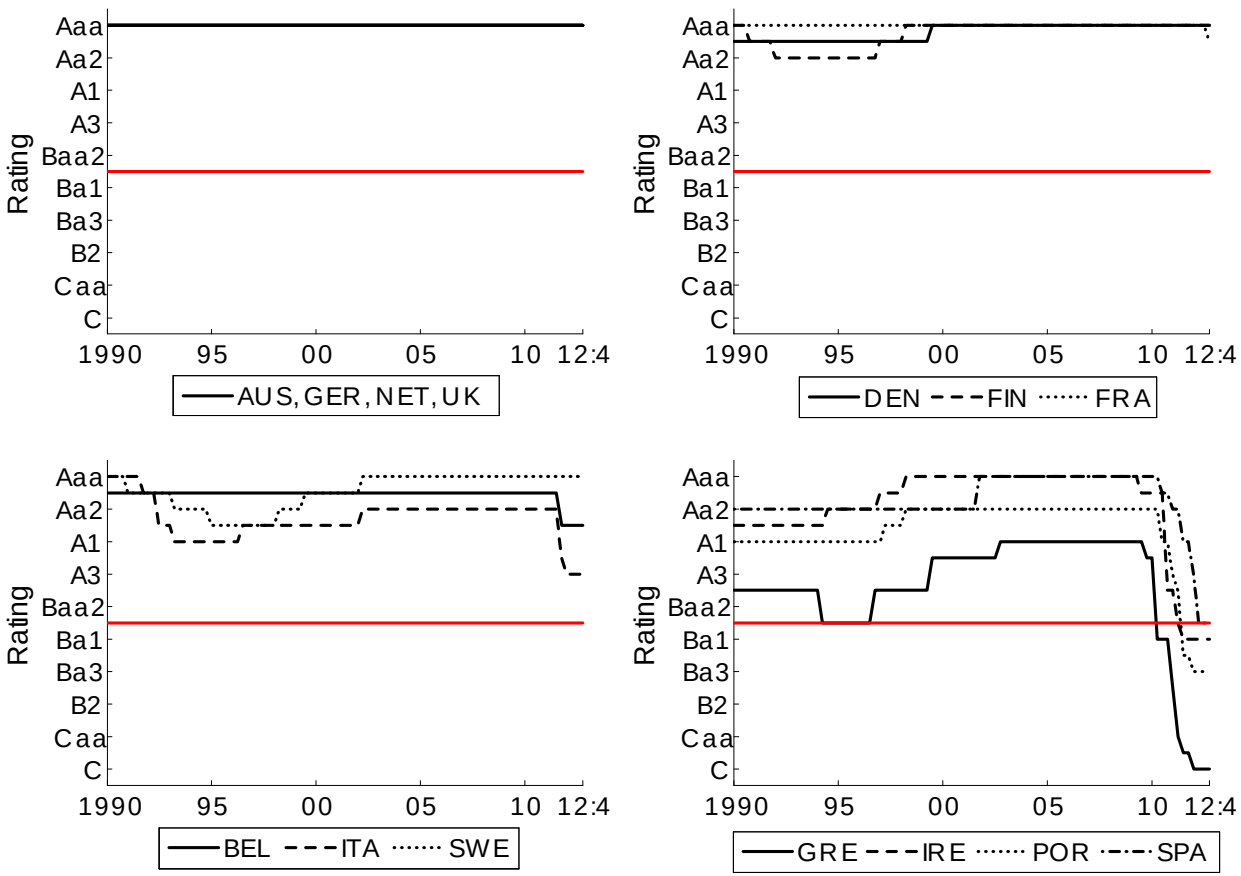
Overview

- New way of constructing sovereign credit ratings
- Based solely on the fiscal stance
- Easy to calculate and transparent to interpret unlike those of the credit rating agencies
- Compares forecasted debt liabilities with the ability to repay debt
- Applied to fourteen EU countries for the period 1995-2012
  Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the U.K.
- Identifies a European debt crisis two years before the official ratings

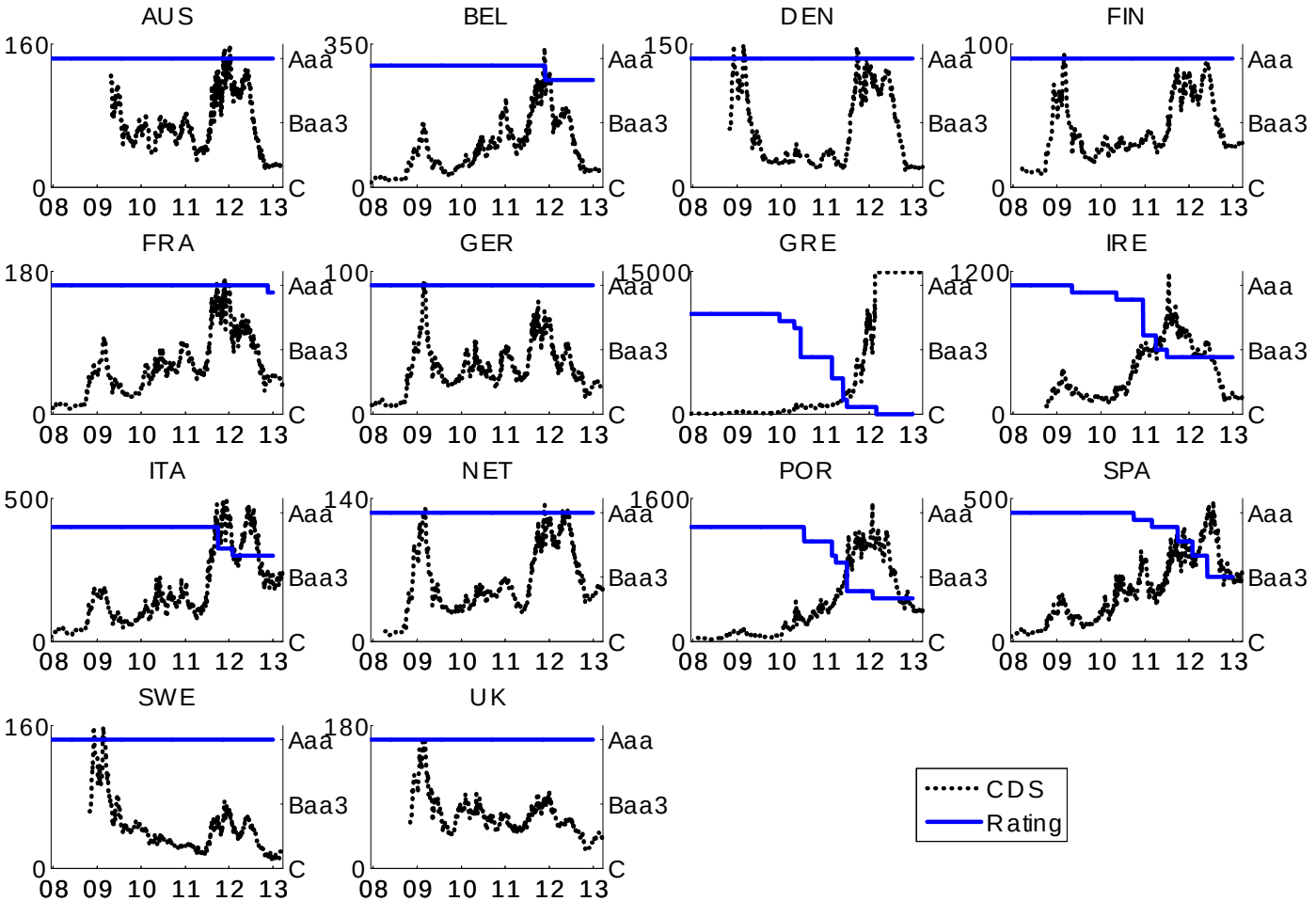
Main findings

- Anticipates the downgrades of Ireland, Spain, Portugal and the U.K. well before 2010 when the CRAs first reacted to the crisis
- CRAs downgraded the UK in 2013
- Downgrades Greece to the lowest rating (coinciding with its highest default probability) from at least mid 2000
- Suggests that the Italian sovereign credit rating has been overstated
- Other countries have ratings similar to those of the CRAs

Preliminary evidence on credit ratings

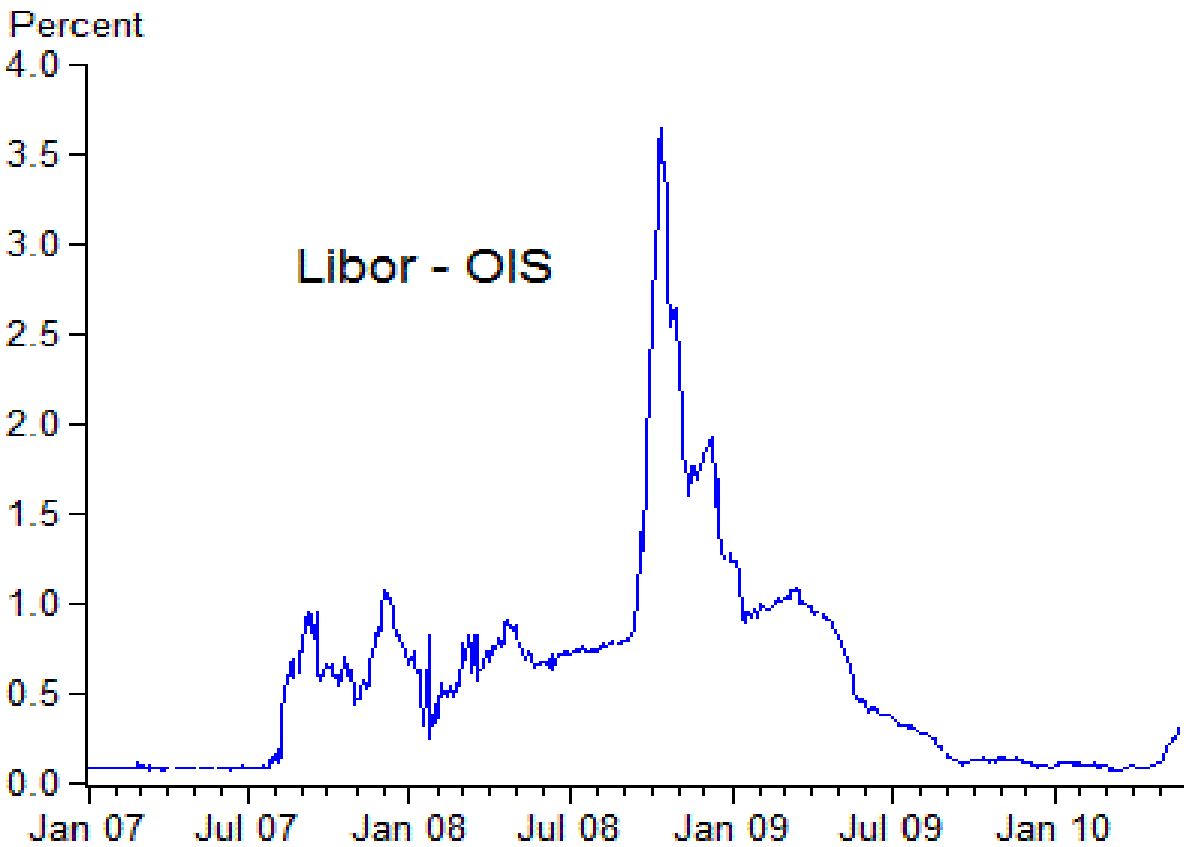


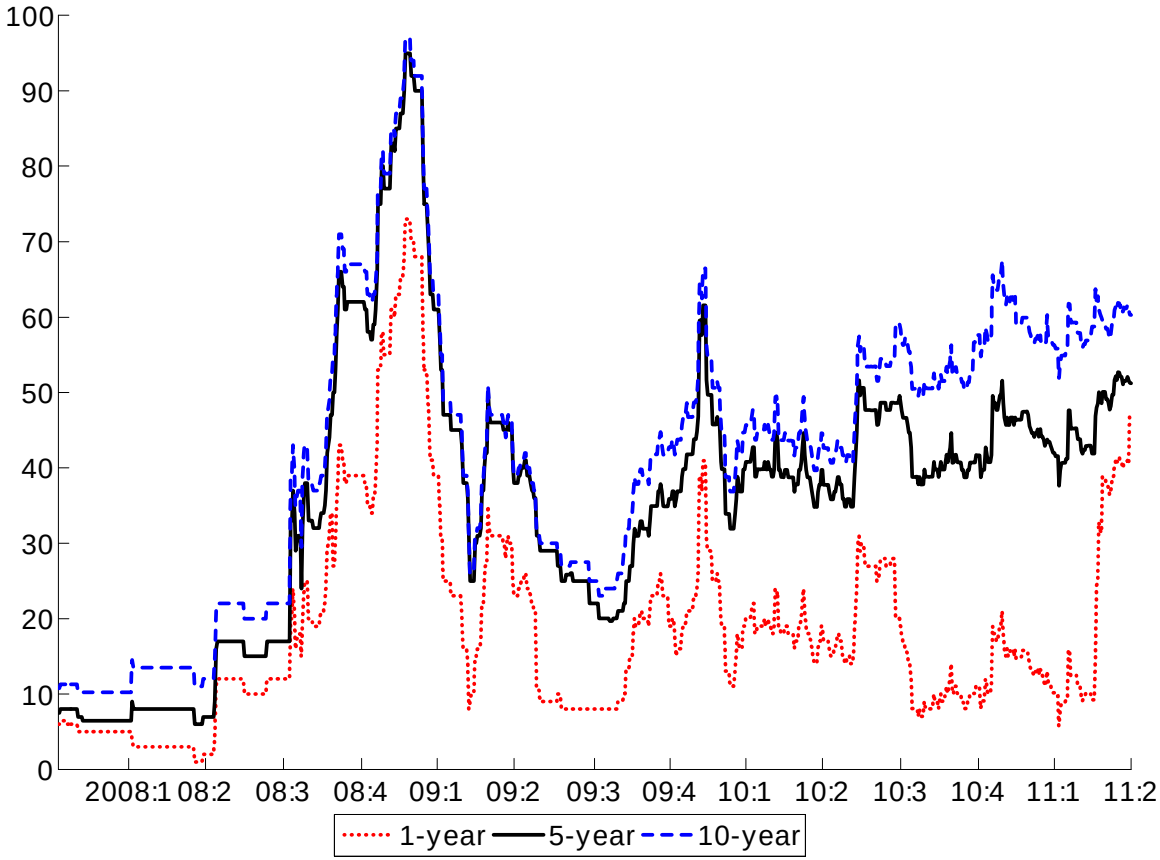
Historic sovereign credit ratings 1990-2012.



Credit ratings and CDS prices 2007-2013.

Evidence from UK credit spreads





U.S. sovereign CDS 2008-2011.

Sept 2009 US CDS's traded at 100bps and by June 2011 51bps (Japan 52, Germany 26) yet still the US received the highest rating by all CRAs

Fiscal sustainability

- The emphasis in the analysis of fiscal policy has been on its sustainability
- This has focused mainly on econometric tests of whether, given the time series properties of deficits and debt, government surpluses are sufficient to payoff debt in the very long run
- From a policy perspective this is not a very interesting question as governments can always say that in due course they will change policy to achieve sustainability
- What is required instead is a measure of the fiscal stance that has immediate relevance

- Macro policy has been increasingly geared to maintaining a high credit rating rather than macro stabilization
- This suggests that rather than focus on long term fiscal sustainabilty under unchanged policies, it would be better focus on a country's sovereign credit rating
- This has an immediate effect on the cost of borrowing and hence current policy
- The problems are that during the recent financial crisis the credit rating agencies were slow to adjust credit ratings
- Further, how they determine credit ratings lacks transparency
- These deficiencies makes it difficult to base fiscal policy on official credit ratings
- To be useful we require timely and transparent information on credit ratings

- The three main CRAs (Fitch, Moody and Standard and Poor) have a virtual monopoly on the provision of credit ratings
- This is partly due to their perceived cost to produce
- This paper describes a simple, transparent and easily automated way to construct sovereign credit ratings that could be used to provide a quick benchmark for governments and markets

What is a credit rating?

- An opinion about the likelihood of default of a government.
- Based on
  (i) perceived ability to service debt - fiscal
  (ii) willingness to service debt - non-fiscal
- Credit ratings might therefore be better thought of as measuring the likelihood of default in the absence of a change of fiscal policy

Methodology

- The aim is to forecast the debt-GDP ratio over given time period
- Estimate the distribution of forecast errors
- Then assess the probability that it will exceed a default threshold before the end of the horizon
- This probability is then mapped into a credit rating using Moody's tables
- The theoretical basis of the analysis is the inter-temporal government budget constraint (IGBC)

- The forecasts are made using a rolling-window VAR model that reflects the IGBC and picks up structural change
- The default threshold involves obtaining a level of the debt-GDP ratio above which the current fiscal stance is not sustainable
  - obtained from an open economy DSGE model with distortionary taxation.
- We use an adaptation to government debt of Merton's (1974)'s measure of distance-to-default and default probability.
- Problem not dissimilar to pricing an American option
- The debt threshold is derived using an RBC model with an elastic labour supply, distortionary taxation and the concept of fiscal limits

Sovereign credit ratings and the CRAs' procedures

- The three main CRAs are Fitch, Moody and Standard and Poor
- CRAs currently view a sovereign credit rating as being closely related to a government's ability to meet its financial obligations.
- Their methodologies are ultimately based on the individual judgments of rating analysts
- No CRA uses a mathematical formula or an economic model to measure the credit rating
- Instead, CRAs have sovereign risk units in charge of assigning new credit ratings and of monitoring and reviewing the existing ratings
- Sovereign ratings are made by request
- A preliminary rating recommendation needs to be ratified (via a voting system) by the members of a rating committee within the CRA.
- The resulting rating is first notified to the issuer and then disseminated to the public through the media.
- Fitch Ratings and Standard & Poor's allow the rating issued by the rating committee to be appealed before dissemination. Moody's does not.

Possible Credit Ratings

Investment grade		Speculative grade	
Long-term	Short-term	Long-term	Short-term
Aaa	Prime - 1	Ba1	Not Prime
Aa1	Prime - 1	Ba2	Not Prime
Aa2	Prime - 1	Ba3	Not Prime
Aa3	Prime - 1	B1	Not Prime
A1	Prime - 1	B2	Not Prime
A2	Prime - 1/2	B3	Not Prime
A3	Prime - 1/2	Caa	Not Prime
Baa1	Prime - 2	Ca	Not Prime
Baa2	Prime- 2 or 3	C	Not Prime
Baa3	Prime-3		

Source: www.moodys.com

Mapping default probabilities into credit ratings by time to maturity

Moody's ratings

Years	1	2	3	4	5	6	7	8	9	10
Rating					Sovereign					
Aaa	0	0	0	0	0	0	0	0	0	0
Aa	0	0	0	0	0	0	0	0	0	0
A	0	0	0	0	0	0	0	0	0	0
Baa	0	0.476	0.997	1.57	2.207	2.855	2.855	2.855	2.855	2.855
Ba	0.769	1.746	3.433	5.349	7.435	8.949	11.118	13.951	16.416	18.882
B	3.391	7.039	9.204	12.11	15.096	17.986	20.085	21.227	22.735	24.59
Caa-C	23.636	27.727	32.823	32.823	32.823	32.823	32.823	32.823	32.823	32.823

Source: Moody's (2011)

- This default probability profile is limited to 7 out of the 19 categories in the table
- Therefore use a two-stage linear interpolation for the missing observations.
- With a quarterly mapping for the whole 10-year period

Measuring the probability of sovereign default

- The conceptual framework is adapted from Merton's (1974) model of credit risk

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$$\begin{aligned} \frac{d_t}{y_t} + (1+\rho_t)\frac{b_{t-1}}{y_{t-1}} &= \frac{b_t}{y_t} \\ \rho_t &= i_t^b - \pi_t - \gamma_t. \end{aligned}$$

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- The h-period ahead forward solution is

$$\frac{b_{t+h}}{y_{t+h}} = -E_t \sum_{j=1}^{h} \left[\Pi_{s=1}^{j} (1+\rho_{t+s}) \frac{d_{t+j}}{y_{t+j}} \right] + \Pi_{s=1}^{h} (1+\rho_{t+s}) \frac{b_t}{y_t},$$

- p_{t+h} = the probability of defaulting in period $t+h$ given information up to period t

$$p_{t+h} = \Pr\left(\frac{b_{t+h}}{y_{t+h}} \geq \overline{\frac{b_{t+h}}{y_{t+h}}} | \frac{b_t}{y_t}\right),$$

where $\overline{\frac{b_{t+h}}{y_{t+h}}}$ is the default threshold of the debt-GDP ratio and $\Pr(.)$ is assumed to be the normal probability density function

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- $p_{t,t+h}$= the probability of sovereign default by period $t+h$ (hazard rate) is the probability of not defaulting prior to year $t+h$ but defaulting in year $t+h$

$$p_{t,t+h} = p_{t+h}\left(1-p_{t+h-1}\right)\left(1-p_{t+h-2}\right)...\left(1-p_{t+1}\right)$$

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- The probability of default in any period between t and $t+h$ is therefore

$$p^c_{t,t+h} = \Sigma^h_{j=1} p_{t,t+j}$$

The debt-GDP ratio at time $t+1$ may be decomposed into

$$\begin{aligned} \frac{b_{t+1}}{y_{t+1}} &= E_t \frac{b_{t+1}}{y_{t+1}} + \xi_{t+1} \\ \xi_t &= \sigma_t \varepsilon_t \\ \varepsilon_t &\sim i.i.d.(0,1) \end{aligned}$$

Hence

$$\begin{aligned} \frac{b_{t+h}}{y_{t+h}} &= E_t \frac{b_{t+h}}{y_{t+h}} + \eta_{t+h} \\ \eta_{t+h} &= \Sigma_{s=1}^{h} \xi_{t+s} \\ V_t(\eta_{t+h}) &= \sigma^2_{\eta,t+h} = \Sigma_{s=1}^{h} \sigma^2_{t+s} \end{aligned}$$

The probability of sovereign default in period $t+h$ given information in period t is therefore

$$p_{t+h} = \Pr\left(-DD_{t+h} \leq \zeta_{t+h}\right),$$

where the distance-to-default is

$$\begin{aligned} DD_{t+h} &= \frac{E_t \frac{b_{t+h}}{y_{t+h}} - \overline{\frac{b_{t+h}}{y_{t+h}}}}{\sigma_{\eta,t+h}} \\ \zeta_{t+h} &= \frac{\eta_{t+h}}{\sigma_{\eta,t+h}} \end{aligned}$$

The (cumulative) probability of default in any period between t and $t+h$ is

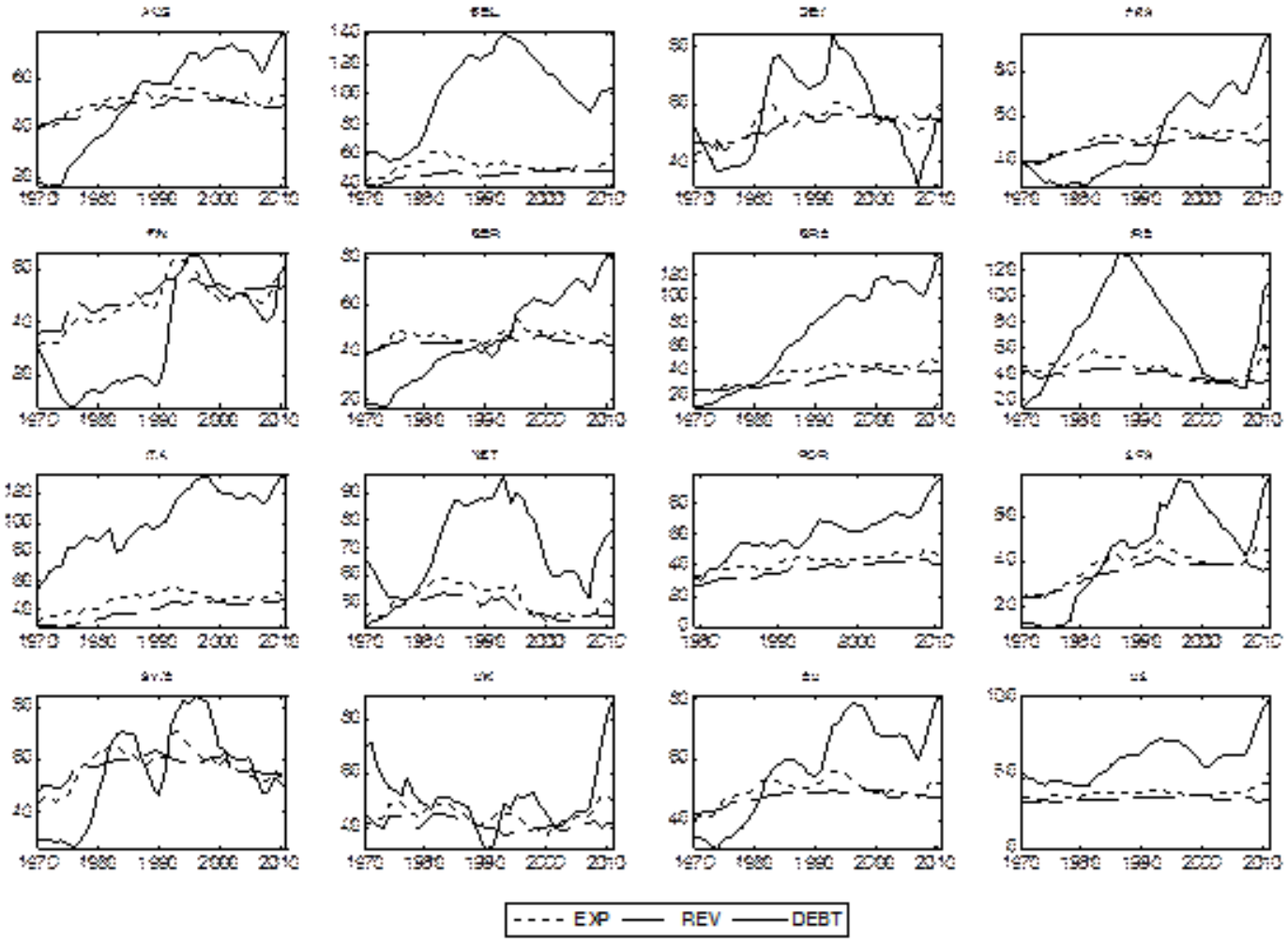
$$p^c_{t,t+h} = \sum_{j=1}^{h} p_{t,t+j}$$

Forecasting sovereign debt and volatility

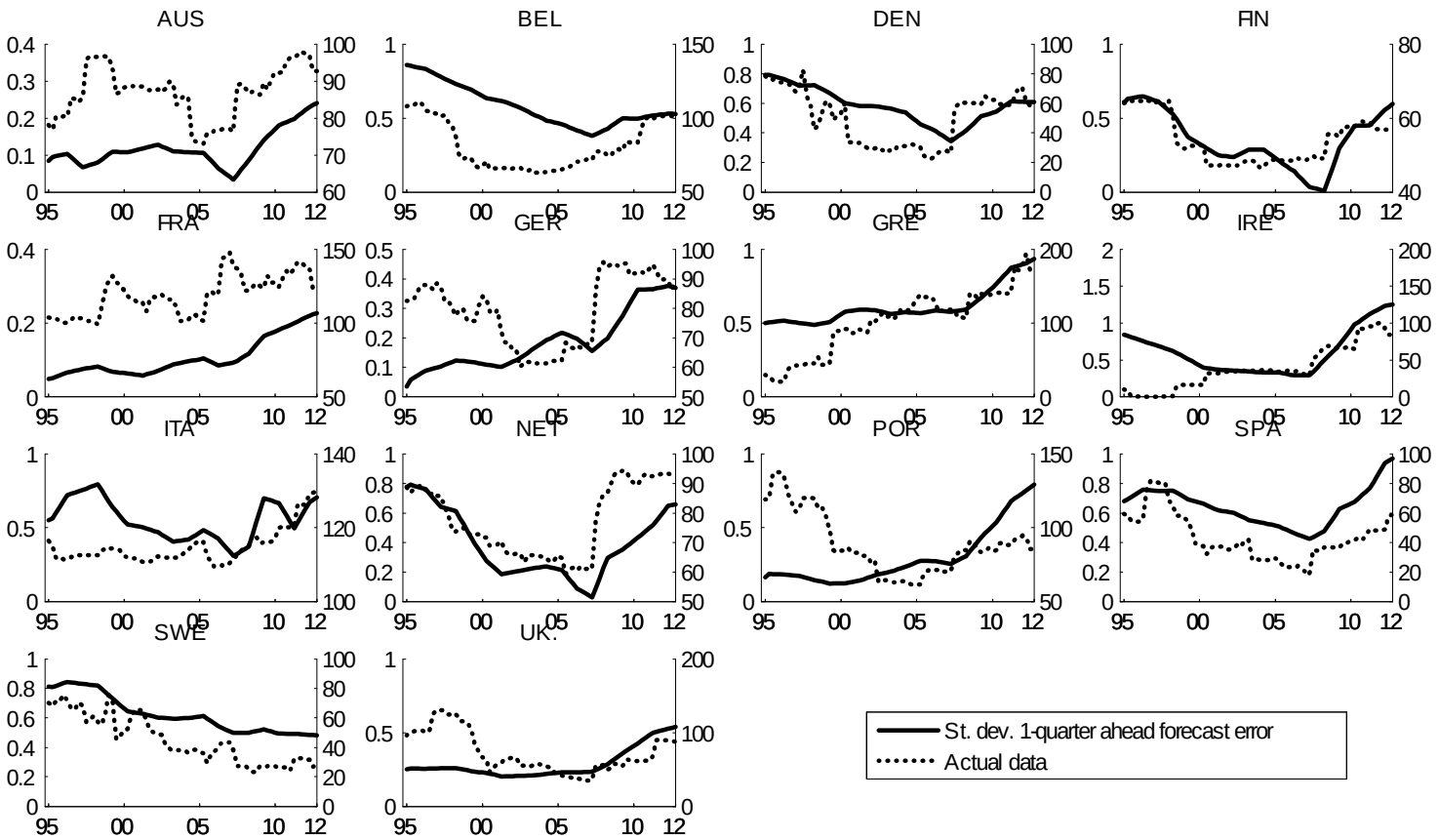
- We forecast using a rolling-window VAR - a ROVAR
- Good for capturing time-varying parameter and volatility shifts
- See Stock and Watson (2007, 2008), Orphanides and Wei (2010), Canova and Ferretti (2012)
- Also, Primiceri (2005) a TVP-SV-VAR
- Sims and Zha (2006) a VAR with Markow-switching parameters and volatility (MS-VAR).
- Wickens (2012) - VARS forecast as well as DSGE models

- ROVAR model estimated with EU quarterly data 1995:1 to 2012:2
- Has two lags and a moving-data window of 40 quarters
- VAR is estimated using data from $t-40$ until date t and forecasts are for $h-$period ahead

EU Expenditures, Revenues and Debt



AUS	*BEL*	*DEN*	*FR*
FIN	*GER*	*GRE*	*IRE*
IT	*NTH*	*POR*	*SP*
SWE	*UK*	*EU*	*US*



Debt-GDP ratio and SD of forecast error

Theory-based debt limits

The debt-GDP limit

- We now specify a DSGE model - an open-economy RBC model with distortionary taxation
- And use this to derive the government's maximum borrowing capacity
- This is the maximum sustainable steady-state debt-GDP limit with respect to the income tax rate - the Laffer hill
- There is no interior maximum wrt consumption or capital taxes or seigniorage
- We ignore seigniorage taxation as EU countries are commiited to an inflation target
- Default is assumed to occur today whenever the forecasted debt-GDP ratio is expected to exceed the debt-GDP limit at some point over the given time horizon

Four measures of the debt-GDP limit

In general, the debt-GDP limit $\frac{b_t}{y_t}^{IGBCL}$ is

$$\frac{b_t}{y_t}^{IGBCL} = -E_t \sum_{j=1}^{\infty} \frac{\frac{g_{t+j}}{y_{t+j}} + \frac{z_{t+j}}{y_{t+j}} - \frac{v_{t+j}}{y_{t+j}}}{\prod_{s=1}^{j} (1 + \rho_{t+s})},$$

g_t = government expenditures on goods and services

z_t = transfers

v_t = government revenues

IGBCL identifies a government's borrowing capacity based on the market's anticipation of the future evolution of fiscal and monetary policy

Natural debt limit (NDL) - Aiyagari (1994)

- state contingent debt in every possible state by eliminating all government expenditures

$$\frac{b_t}{y_t}^{NDL} = E_t \sum_{j=1}^{\infty} \frac{\frac{v_{t+j}}{y_{t+j}}}{\prod_{s=1}^{j} \left(1+\rho_{t+s}\right)}.$$

NDL cuts government expenditures to the minimum as $\frac{g}{y} = \frac{z}{y} = 0$

Fiscal limit (FL) - Davig, Leeper and Walker (2010, 2011)

- the expected present value of future primary deficits under the assumption that tax revenue is maximized in each period and there will be no unanticipated changes in the conduct of government expenditure policy

$$\frac{b_t}{y_t}^{FL} = E_t \sum_{j=1}^{\infty} \frac{\frac{d_{t+j}}{y_{t+j}}^{FL}}{\prod_{s=1}^{j} (1+\rho_{t+s})}$$

$$\left\{ \frac{d_{t+j}}{y_{t+j}}^{FL} = \frac{g_{t+j}}{y_{t+j}} + \frac{z_{t+j}}{y_{t+j}} - \frac{v_{t+j}^{\max}}{y_{t+j}} \right\}_{j=0}^{\infty}$$

FL maximises borrowing for given expenditures by maximising τ^n and τ^k with $\tau^{n,\max}$ and $\tau^{k,\max}$

Maximum debt limit (MDL)

- maximizes tax revenues whilst setting government expenditure and transfers to zero in FL
- government can no longer use unanticipated fiscal policy to finance more debt and would need to resort to monetary policy

$$\frac{b_t}{y_t}^{MDL} = E_t \sum_{j=1}^{\infty} \frac{\frac{v_{t+j}^{\max}}{y_{t+j}}}{\prod_{s=1}^{j} (1+\rho_{t+s})}.$$

When MDL is satisfied a government can no longer use unanticipated changes in fiscal policy to finance additional debt and so would then need to resort to monetary policy.

Model

Households maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\log c_t + \psi \log\left(1 - n_t\right)\right]$$

subject to

$$\begin{aligned}(1+\tau_t^c)c_t + k_t + b_t^D + s_t f_t \quad &= \quad (1-\tau_t^n) w_t n_t + \left(r_t^k - \delta\right)\left(1-\tau_t^k\right) k_{t-1} \\ &\quad + \left(1+r_t\right) b_{t-1}^D + z_t + \left(1+r_t^*\right) s_t f_{t-1}\end{aligned}$$

Total consumption is assumed to satisfy the CES function

$$c_t = \left[\phi\left(c_t^H\right)^{1-\frac{1}{\eta}} + (1-\phi)\left(c_t^F\right)^{1-\frac{1}{\eta}}\right]^{\frac{1}{1-\frac{1}{\eta}}},$$

Firms

$$y_t = k_t^{\alpha} \left(A_t n_t \right)^{1-\alpha}$$

Government budget constraint

$$\begin{aligned} g_t + \left(1 + r_t\right) b_{t-1}^D + \left(1 + r_t\right) b_{t-1}^F + z_t &= \tau_t^c c_t + \tau_t^n w_t n_t \\ &\quad + \tau_t^k \left(r_t^k - \delta \right) k_{t-1} + b_t^D + b_t^F \end{aligned}$$

Balance of payments and the national income identities

$$\begin{aligned} s_t f_t - b_t^F &= x_t + \left(1 + r_t^*\right) s_t f_{t-1} - \left(1 + r_t\right) b_{t-1}^F \\ y_t &= c_t + g_t + k_t - \left(1 - \delta\right) k_{t-1} + x_t \end{aligned}$$

Comments

- The existence of an equilibrium solution implies that the intertemporal GBC is satisfied and that a government cannot roll over its liabilities forever
- and governments can borrow at a rate that allows an equilibrium to exist.
- No default risk premium in r_t^b - like Davig, Leeper and Walker (2010, 2011) and Bi (2011)

Steady-state solution

Maximise $\frac{v}{y}$ wrt to τ^n and τ^k taking τ^c, $\frac{g}{y}$ and $\frac{z}{y}$ given

$$\frac{b^D + b^F}{y} = \frac{b}{y} = \frac{1}{r^*} \left\{ \begin{array}{c} \tau^c \chi \left(\frac{1}{\varphi k} - 1 \right) + \tau^n (1 - \alpha) \\ + \tau^k \alpha \left[1 - \delta \left(\frac{\beta^{-1} - 1}{1 - \tau^k} + \delta \right)^{-1} \right] - \frac{g}{y} - \frac{z}{y} \end{array} \right\}$$

$$\begin{aligned} \chi &= \frac{(1 - \tau^N)}{\psi(1 + \tau^C)} (1 - \alpha), \quad \varphi = \left[\frac{\beta^{-1} - 1 + \delta (1 - \tau^k)}{\alpha A^{1-\alpha} (1 - \tau^k)} \right]^{\frac{1}{1-\alpha}} \\ k &= \frac{\mu + (1 + \tau^c)(g + x)}{[(1 + \tau^c)\Omega + \mu\varphi]}, \quad \mu = \frac{1}{\psi} (1 - \tau^n)(1 - \alpha) A^{1-\alpha} \varphi^{-\alpha} \\ \Omega &= (A\varphi)^{1-\alpha} - \delta \end{aligned}$$

Solution for four debt limits

$$\frac{b}{y}^{IGBCL} = \frac{1}{r^*}\left\{\begin{array}{c}\tau^c\chi\left(\frac{1}{\varphi k}-1\right)+\tau^n\left(1-\alpha\right)\\ +\tau^k\alpha\left[1-\delta\left(\frac{\beta^{-1}-1}{1-\tau^k}+\delta\right)^{-1}\right]-\frac{g}{y}-\frac{z}{y}\end{array}\right\}$$

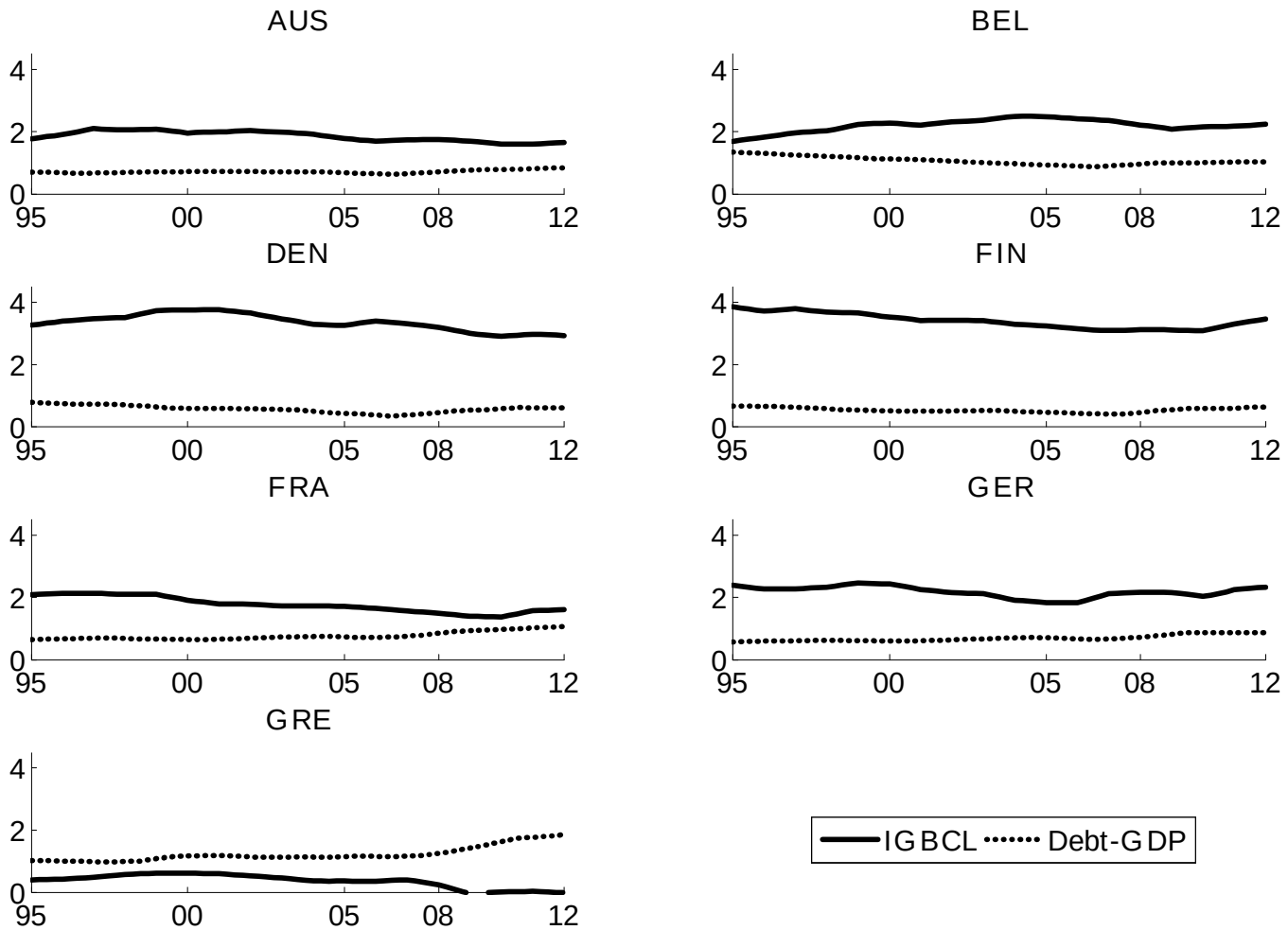
$$\frac{b}{y}^{NDL} = \frac{1}{r^*}\left\{\begin{array}{c}\tau^c\chi\left(\frac{1}{\varphi k}-1\right)+\tau^n\left(1-\alpha\right)\\ +\tau^k\alpha\left[1-\delta\left(\frac{\beta^{-1}-1}{1-\tau^k}+\delta\right)^{-1}\right]\end{array}\right\}.$$

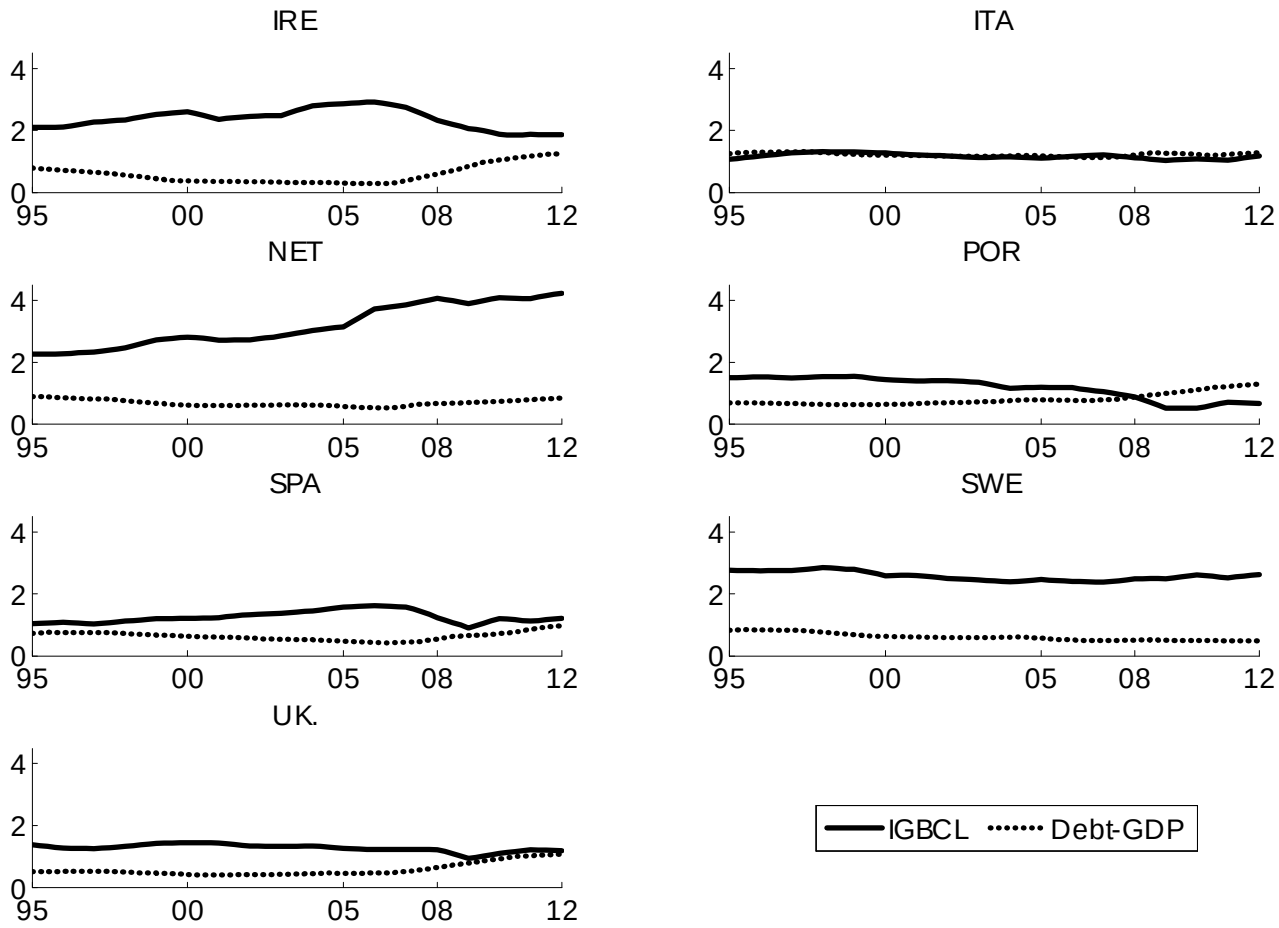
$$\frac{b}{y}^{FL} = \frac{1}{r^*}\left\{\begin{array}{c}\tau^c\chi\left(\frac{1}{\varphi k}-1\right)+\tau^{n,\max}\left(1-\alpha\right)\\ +\tau^{k,\max}\alpha\left[1-\delta\left(\frac{\beta^{-1}-1}{1-\tau^k}+\delta\right)^{-1}\right]-\frac{g}{y}-\frac{z}{y}\end{array}\right\}$$

$$\frac{b}{y}^{MDL} = \frac{1}{r^*}\left\{\begin{array}{c}\tau^c\chi\left(\frac{1}{\varphi k}-1\right)+\tau^{n,\max}\left(1-\alpha\right)\\ +\tau^{k,\max}\alpha\left[1-\delta\left(\frac{\beta^{-1}-1}{1-\tau^k}+\delta\right)^{-1}\right]\end{array}\right\}$$

Actual and sustainable debt under unchanged fiscal policies

Greece's debt is always unsustainable, Ireland and Portugal worsen with crisis

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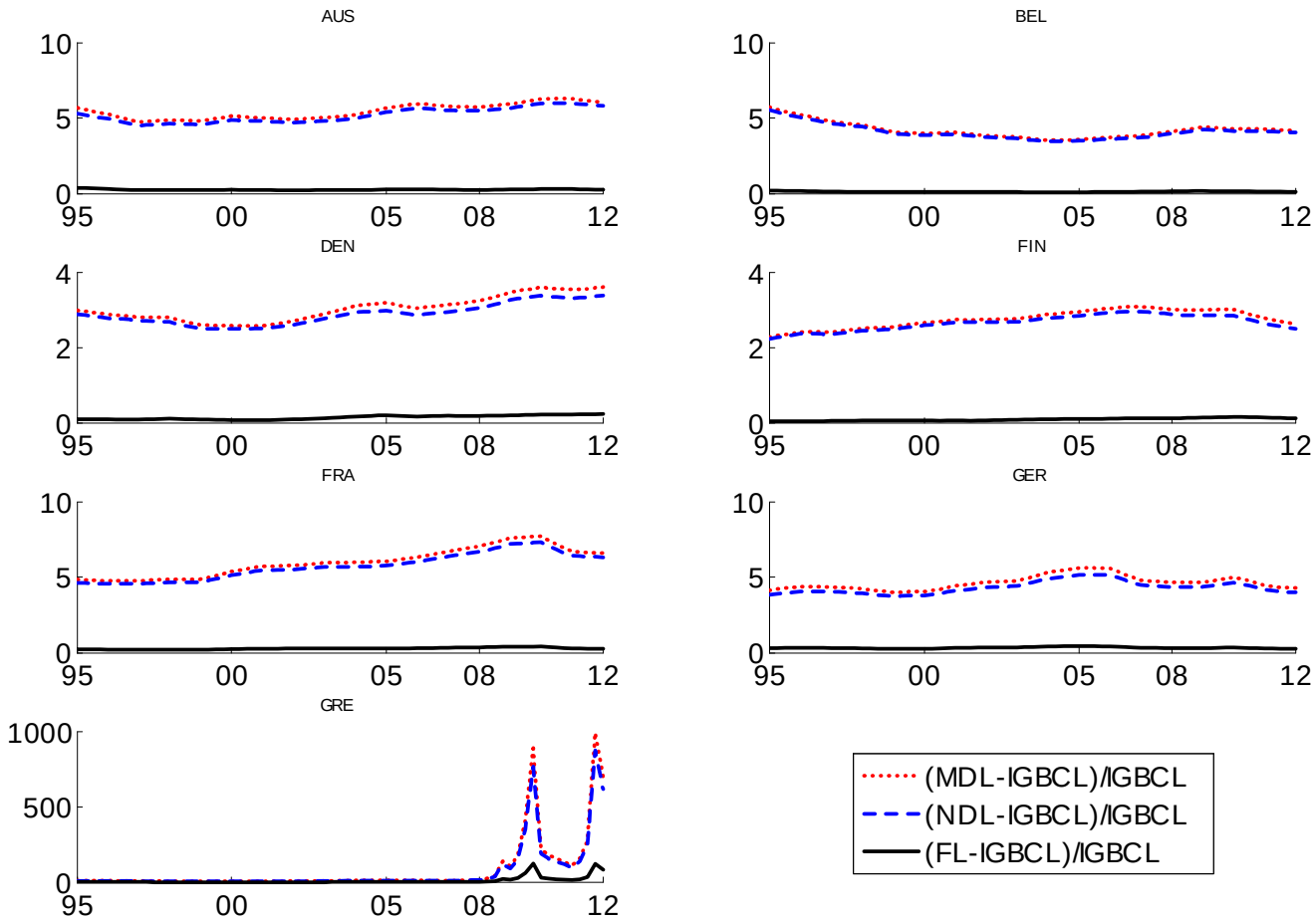
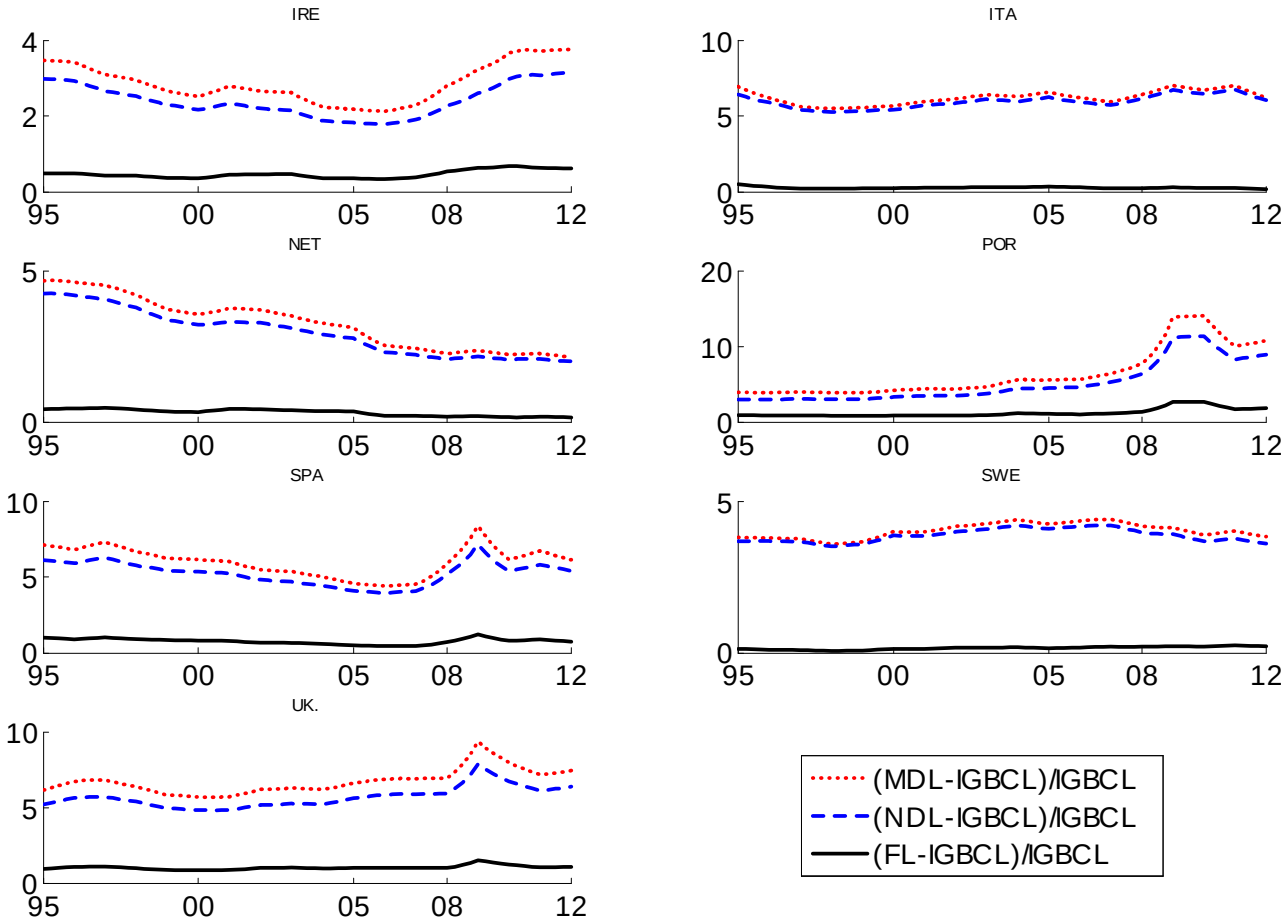
Debt-GDP

Comparing different debt-GDP limits

In general FL is close to IGBCL, implying not much room for additional taxes

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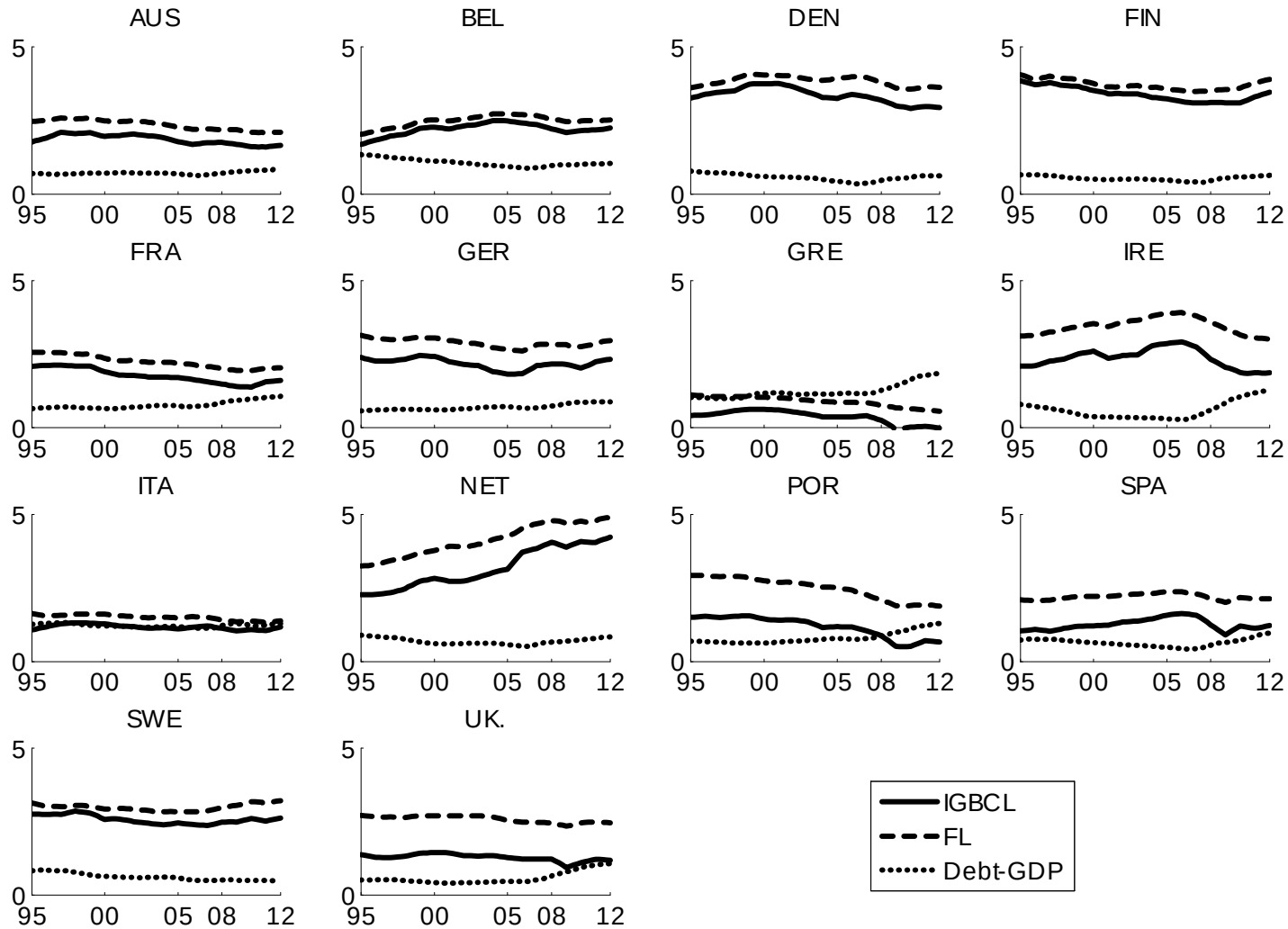
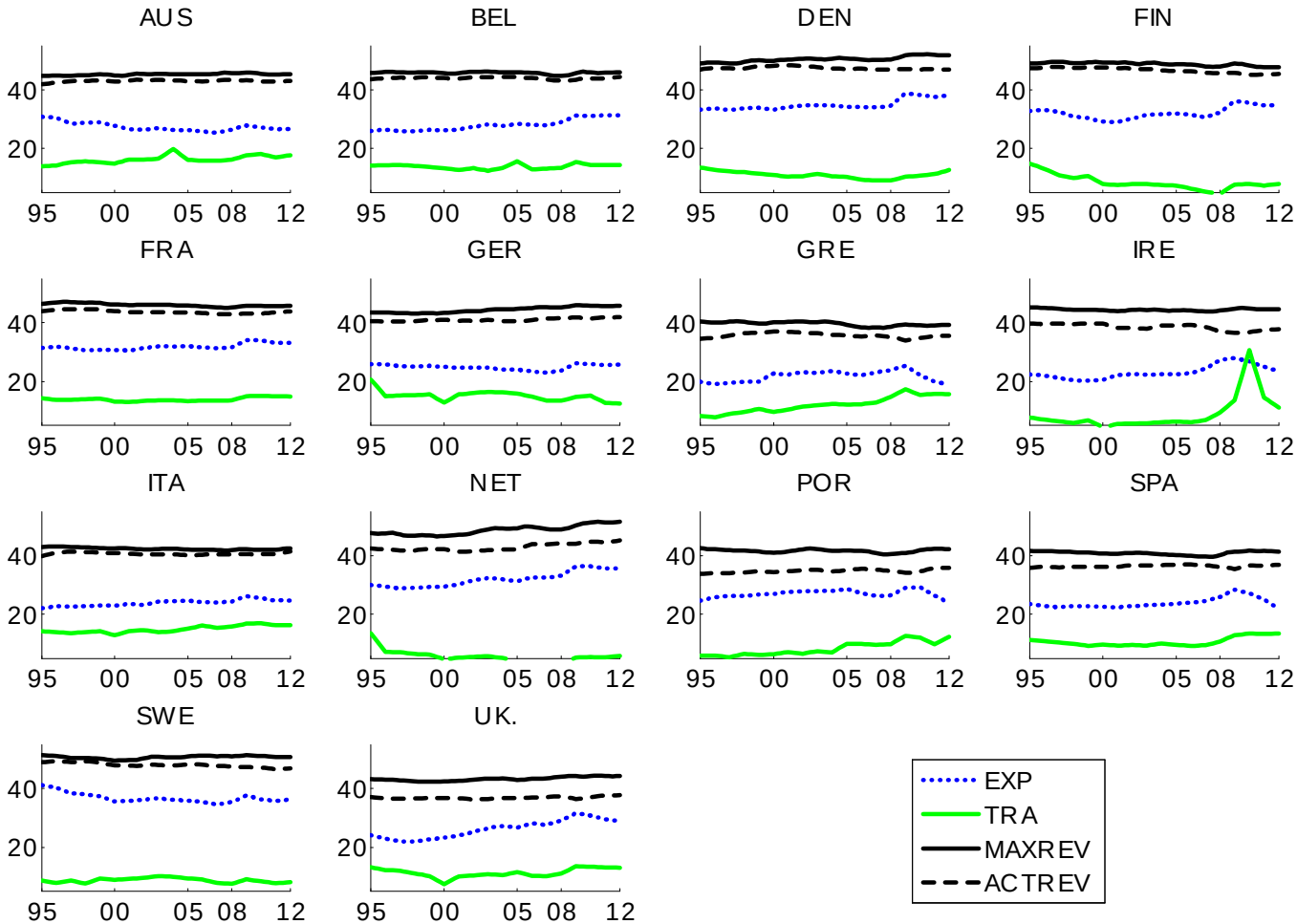
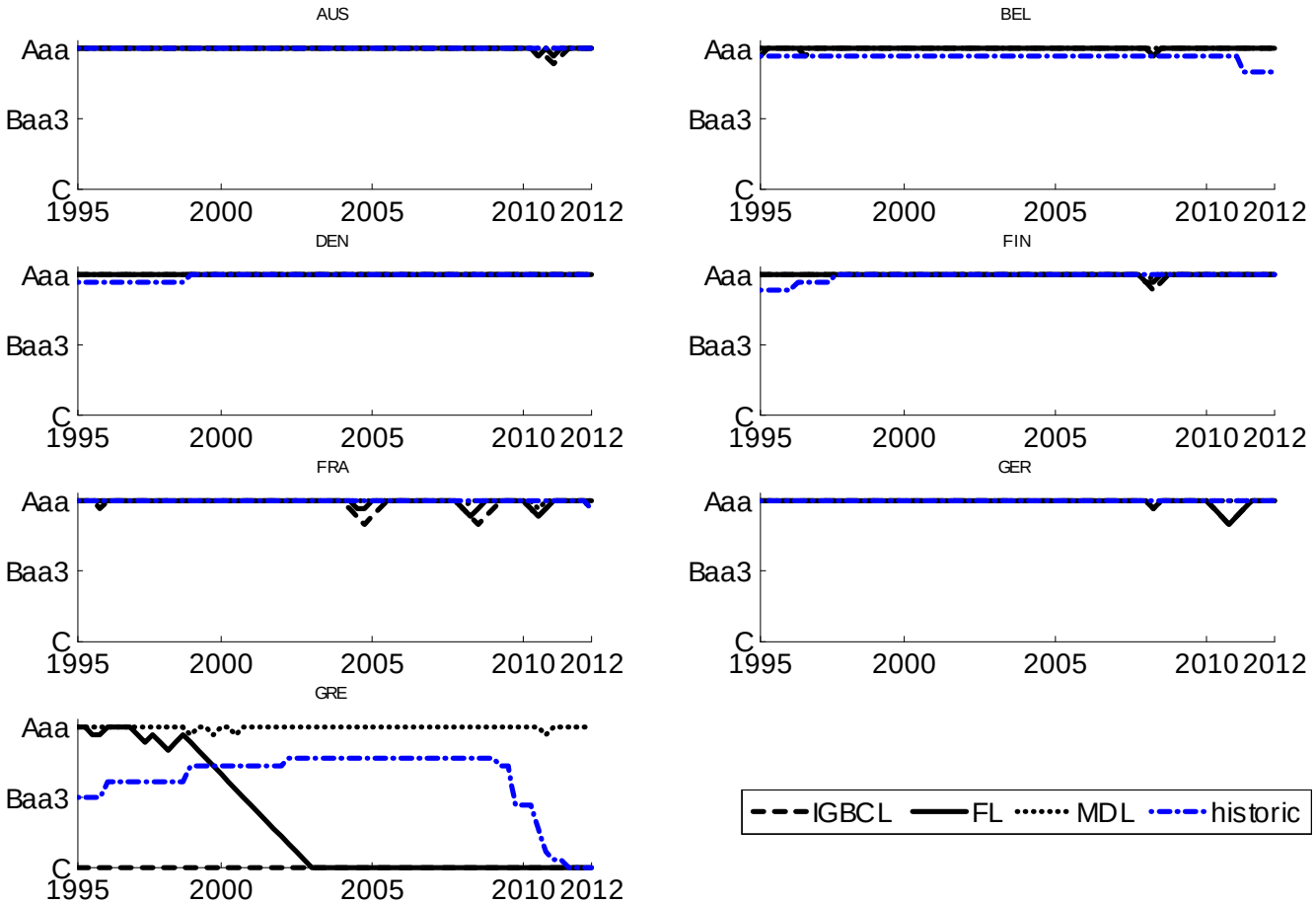


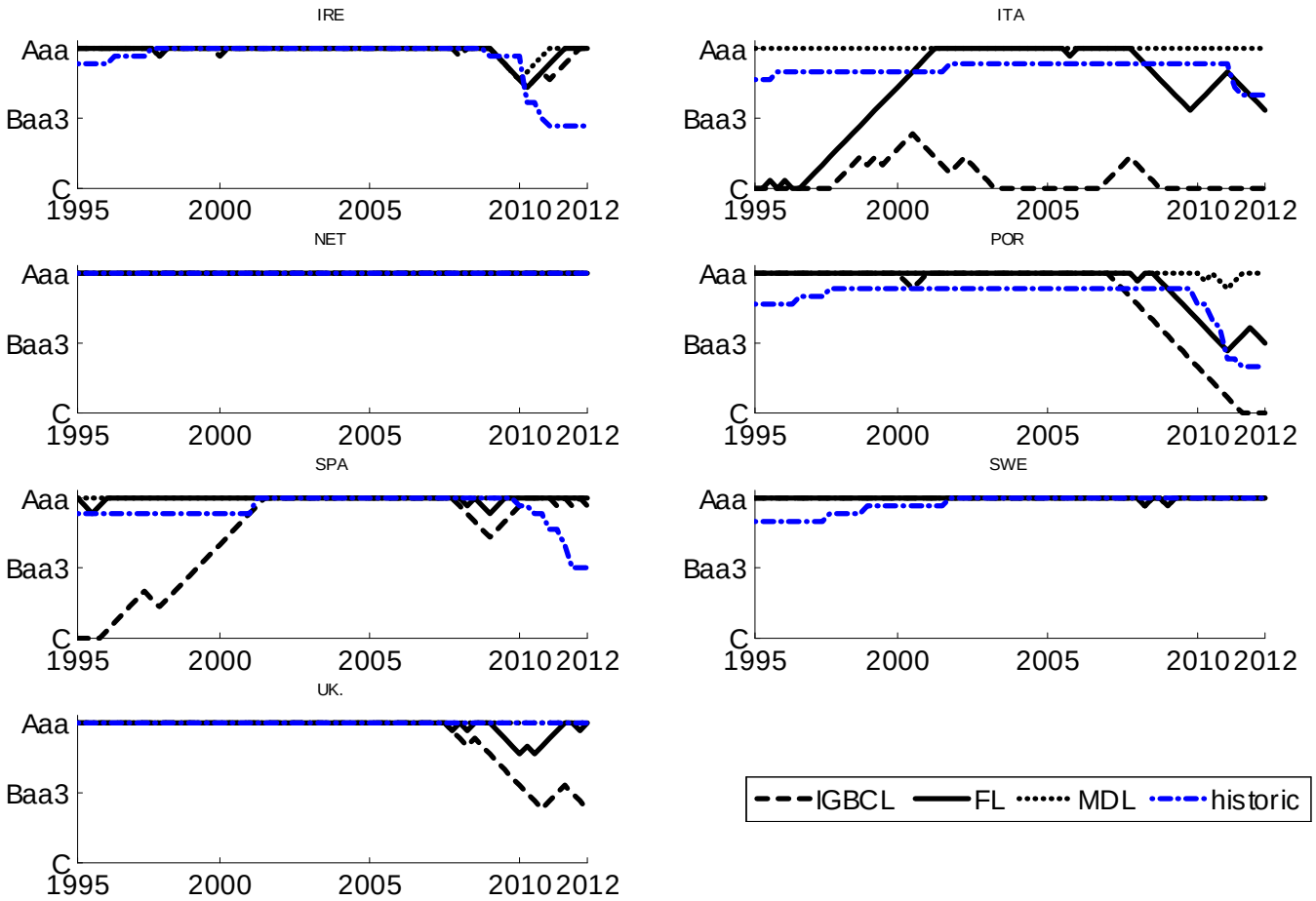
IGBCL, FL limits and debt-GDP ratio



Components of FL debt limit

EU credit ratings for 5-year time horizon

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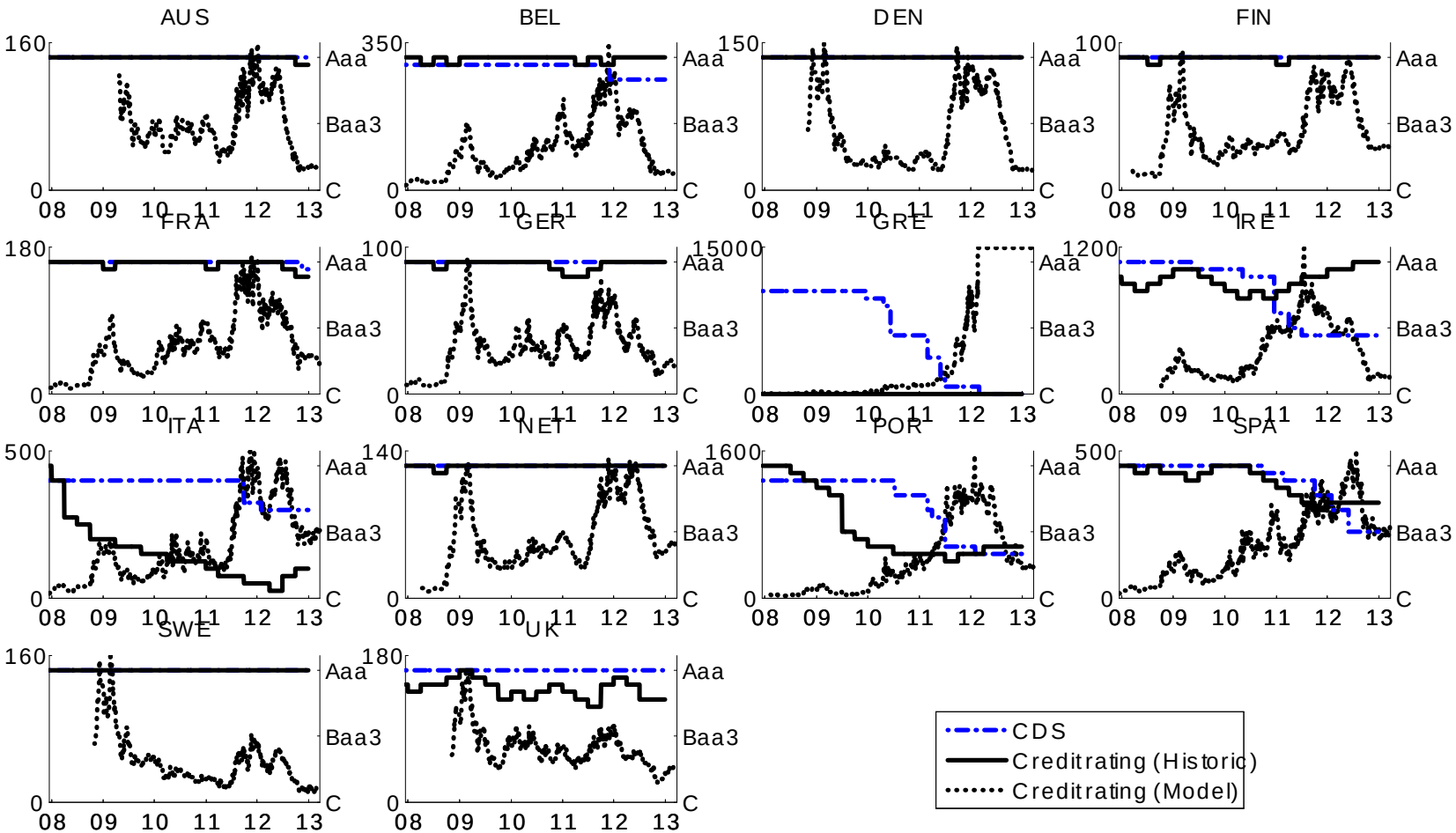
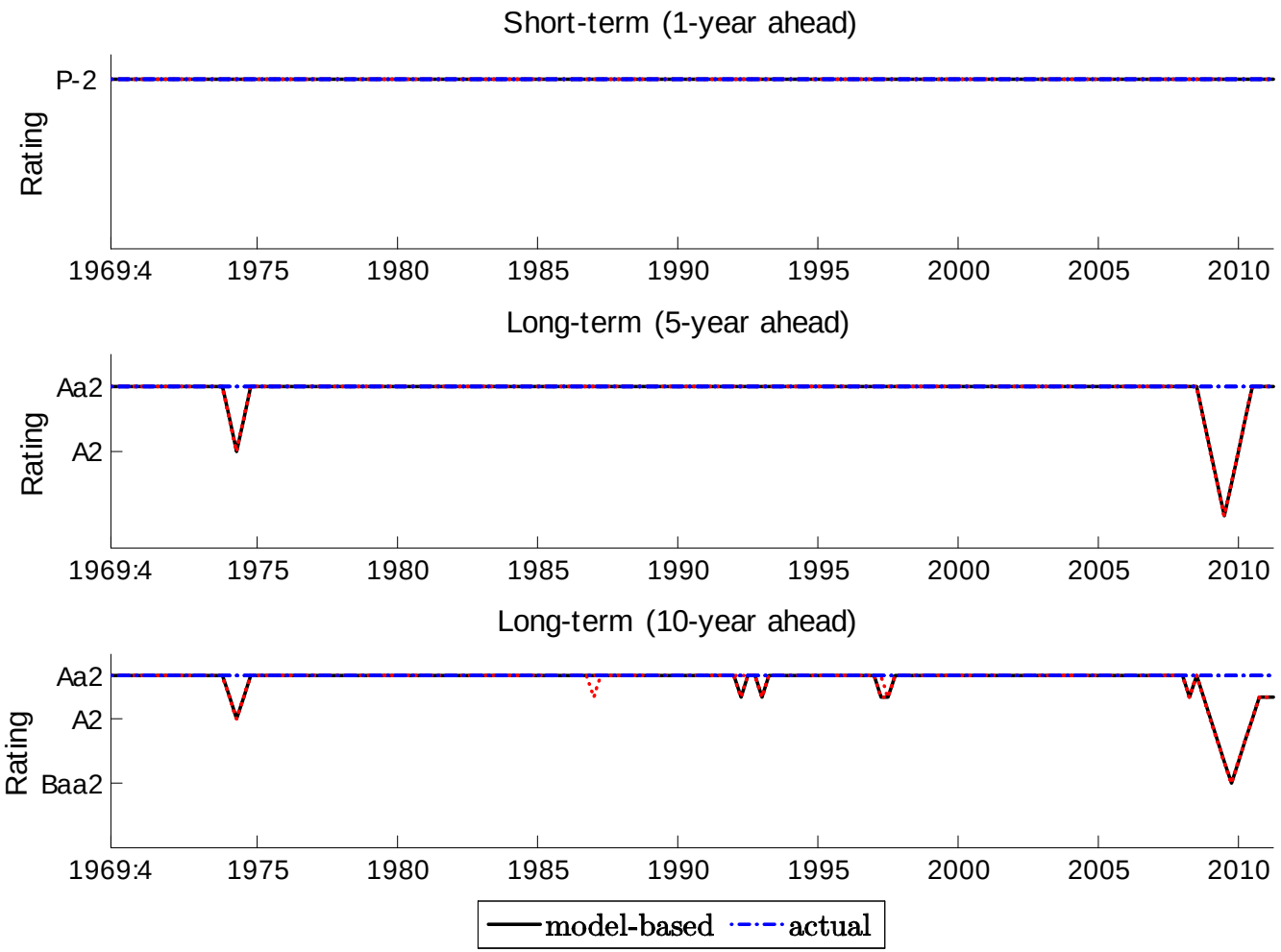


Credit ratings and 5-year CDS prices 2007-13.

US credit rating



Conclusions

- Our model-based credit rating would have identified and signalled to market participants signs of the impending European sovereign debt crisis well before 2010, when the CRAs first reacted to the crisis
- The differences from the credit ratings of the CRAs may be due to them taking into account additional factors to those that arise solely from a country's fiscal stance
- A major cause of the financial crisis in the eurozone was high inflation and over-borrowing due to being able to borrow at the same nominal interest rate but negative real interest rates
- A possible solution is for high inflation countries to use their fiscal policy. This requires not a common deficit limit but an even tighter fiscal policy in high inflation countries.

An adminstrative solution

- High inflation countries must offset an inappropriate monetary policy with fiscal policy.
- This requires not a common deficit limit but an even tighter fiscal policy in high inflation countries.

A market-based solution

- If credit risk was accurately assessed then the probability of default would be reflected in borrowing rates.
- In this way the market could automatically correct for the inherent and unavoidable limitations of eurozone monetary policy.
- Treaty changes, a banking union and common restrictions on fiscal deficits may then be unnecessary.