

Sovereign Credit Ratings in the European Union: A Model-Based Fiscal Analysis

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Introduction

- Motivation - EU downgrades in 2011; EC 2011 proposal; EC 2013 new regulations; EU-based CRA
- Contribution - Black and Scholes model, GBC, model for debt forecasts and debt limits
- Findings - earlier downward shift in the credit rating distribution, fiscal consolidation in the EU
- Outline - historic credit rating, methodology, debt limit, model-based credit rating
- Previous work on U.S. and the U.K.

Historic credit rating

Table 1: Rating scales adopted by the three main CRAs.

	Moody's	Fitch	S&P	Credit quality
Investment grade (I.G.)	Aaa	AAA	AAA	Prime
	Aa1	AA+	AA+	High grade
	Aa2	AA	AA	
	⋮	⋮	⋮	
Speculative grade (S.G.)	Baa3	BBB-	BBB-	Speculative
	Ba1	BB+	BB+	
	Ba2	BB	BB	
	Ba3	BB-	BB-	for recovery
	⋮	⋮	⋮	
	Ca	CC	CCC	
	C	C		In default
	DDD, DD, D	D		

Source: Authors' classification based on Gaillard (2012)

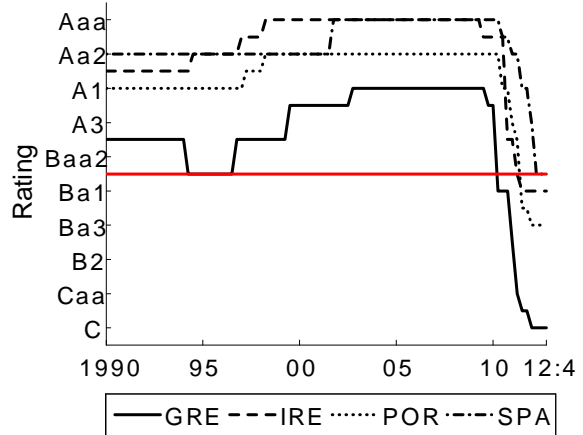
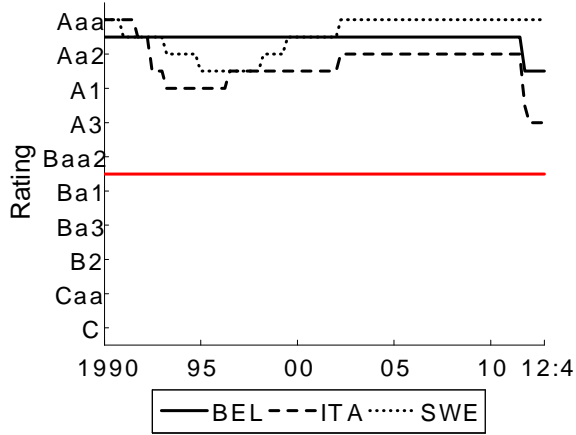
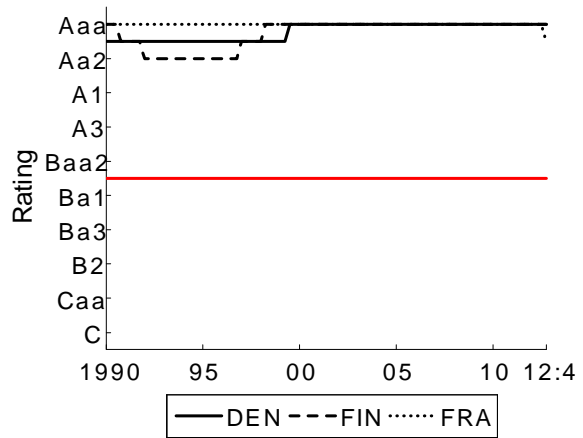
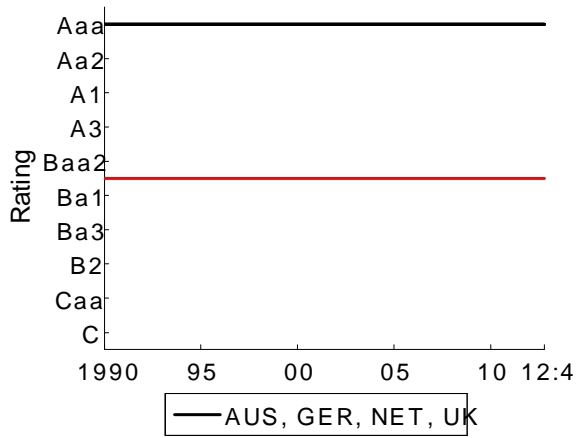
Facts about historic credit ratings of EU countries

1. The sovereign credit ratings of the EU14 countries taken as a group has been higher than those of other countries.
2. The cross-section distribution of the EU14 countries sovereign credit ratings has been stable within the investment grade at least until 2010.
3. Sharp changes in this distribution have occurred, particularly since 2010.
4. Fluctuations in EU14 sovereign credit ratings have increased as the ratings have fallen.
5. Changes in the sovereign credit ratings of several EU 14 countries appear to be unrelated to the market's perception of the probability of sovereign default.

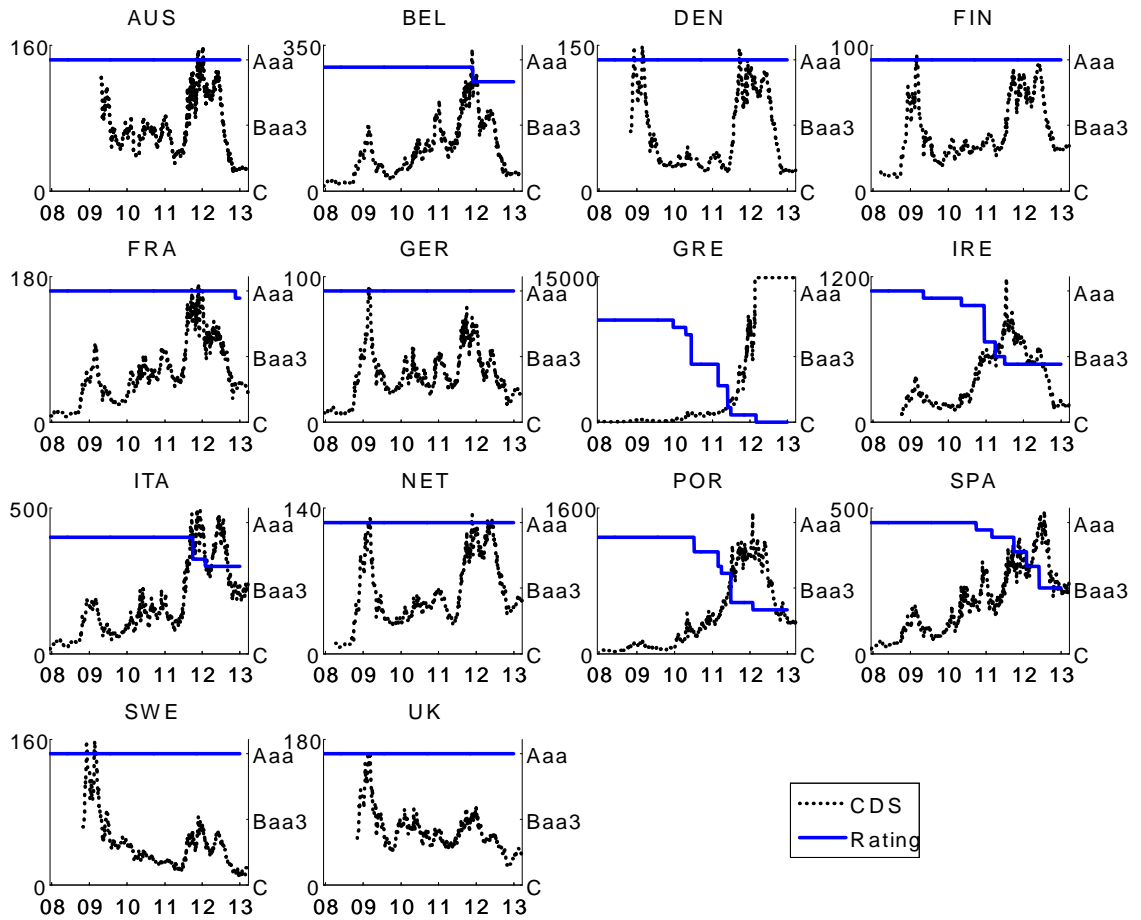
Table 2: Distribution of historic sovereign credit ratings of EU14 countries at selected dates.

	90	95	00	05	06-08	09	10	11	12
Aaa	50%	36%	57%	71%	71%	64%	57%	57%	50%
Aa	36%	43%	36%	21%	21%	29%	21%	7%	14%
A	7%	14%	7%	7%	7%	7%	7%	14%	7%
Baa	7%	7%	0%	0%	0%	0%	7%	0	7%
Ba	0%	0%	0%	0%	0%	0%	7%	14%	14%
B	0%	0%	0%	0%	0%	0%	0%	0	0%
C	0%	0%	0%	0%	0%	0%	0%	7%	7%
Share of investment grade (in percentage)									
EU14	100	100	100	100	100	100	93	79	79
ARC	86	78	59	63	n.a.	n.a.	61	n.a.	60

Notes: ARC=All Rated Countries in a specific year; n.a.=not available.
Source: Moody's (2012)



Historic sovereign credit rating of EU14 countries,
1990-2012.



Sovereign credit ratings and 5-year credit default swap prices for EU14 countries, 14/12/2007 - 22/03/2013.

Methodology

- Adapt to GBC Black–Scholes (1973) formula for probability of exercising a European-style call option.
- This gives sovereign default probabilities at different time horizons.
- Use CRAs tables to convert into credit rating.
- Debt limit: State-dependent measures from a DSGE model of the economy. Time series of the maximum borrowing capacity of an economy.
- (1) Default probability, (2) mapping credit rating, (3) debt-GDP forecasts and volatility; (4) debt limit.

Methodology (Default probability)

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

$$\text{default threshold (debt limit): } \overline{\frac{b_{t+h}}{y_{t+h}}}$$

$$p_{t,t+h} = p_{t+h} (1 - p_{t+h-1}) (1 - p_{t+h-2}) \dots (1 - p_{t+1})$$

$$p_{t+h} = \Pr \left(\frac{b_{t+h}}{y_{t+h}} \geq \overline{\frac{b_{t+h}}{y_{t+h}}} \mid \Phi_t \right)$$

$$\text{distance-to-default: } DD_{t+h} = \frac{E_t \frac{b_{t+h}}{y_{t+h}} - \overline{\frac{b_{t+h}}{y_{t+h}}}}{\sigma_{\eta,t+h}}$$

Methodology (Credit rating)

Rating	Cumulative default probability				
	Long-term	1-year	5-year	10-year	average
Aaa	0.000	0.000	0.000	0.000	0.000
Aa1	0.008	0.215	0.715	0.715	0.265
Aa2	0.015	0.430	1.429	1.429	0.529
Aa3	0.023	0.646	2.144	2.144	0.794
A1	0.030	0.861	2.858	2.858	1.058
A2	0.038	1.076	3.573	3.573	1.323
⋮	⋮	⋮	⋮	⋮	⋮
B3	2.724	11.158	18.541	18.541	10.887
Caa	11.142	21.083	26.005	26.005	19.711
Ca	19.561	31.008	33.469	33.469	28.534
C	27.979	40.933	40.933	40.933	37.358

Source: www.moodys.com; and authors' calcs

Table 3: Mapping from cumulative default probabilities to sovereign credit rating.

Debt limit

- Ad hoc?
 - agnostic (ability/willingness)
 - Reinhart, Rogoff and Savastano (2003): likely to vary from country to country, as well as over time
- From a structural model of the economy
 - Open economy RBC with distortionary taxation on income from capital, labor and consumption
 - Similar to Trabandt and Uhlig (2011)
 - Financial ability only
 - Anticipated or unanticipated fiscal policy

Debt limit (model)

- Preferences

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, 1 - n_t)$$

- Households budget constraint

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

- Consumption

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

- Production

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

- Government budget constraint

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

- BoP

$$s_t f_t - b_t^F = x_t + (1 + r_t^*) s_t f_{t-1} - [1 + (1 - \xi_t) r_t - \Xi_t] b_{t-1}^F$$

- Economy constraint

$$y_t = c_t + g_t + k_t - (1 - \delta) k_{t-1} + x_t$$

Debt limit (model)

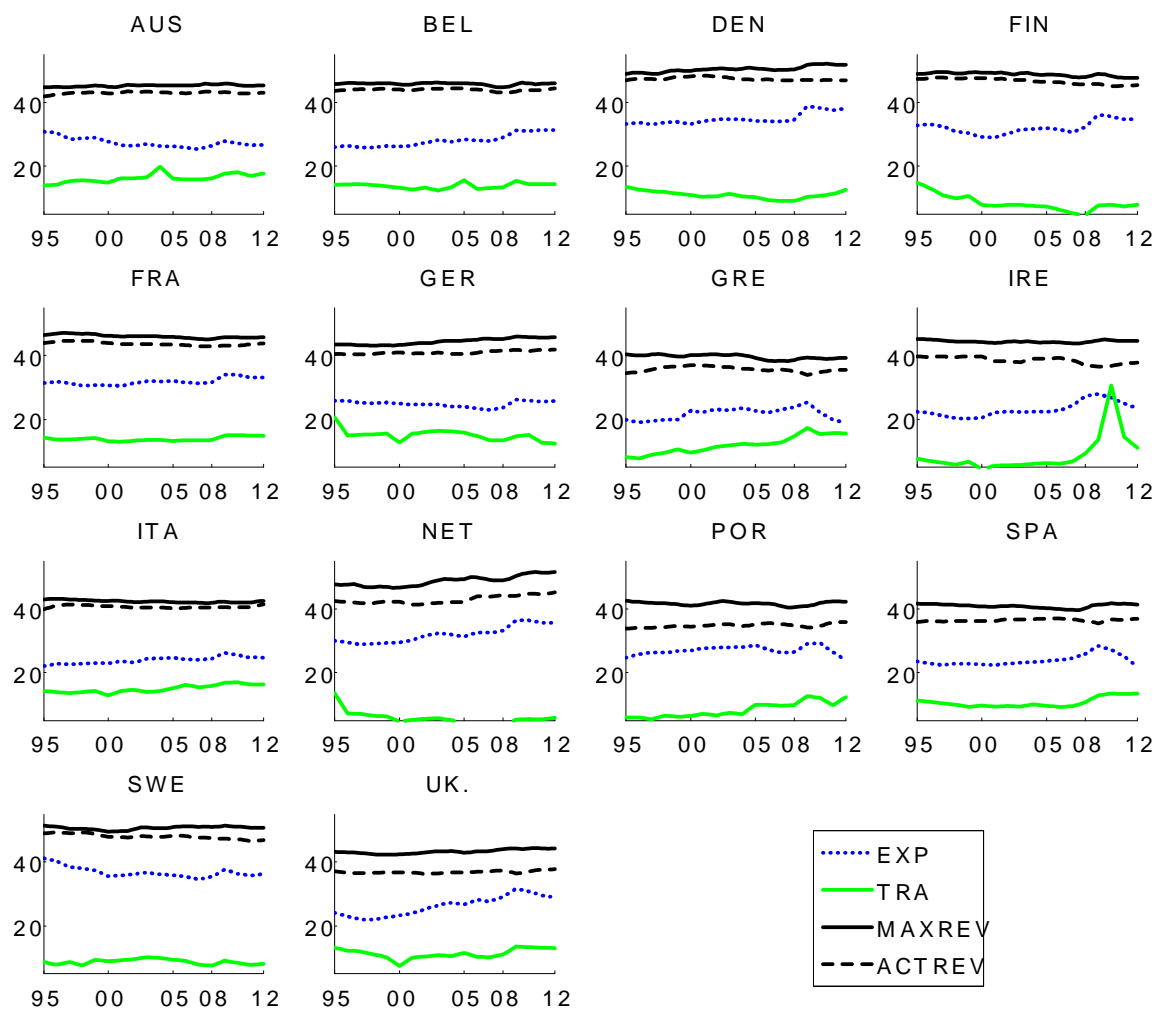
Stationary equilibrium solution

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

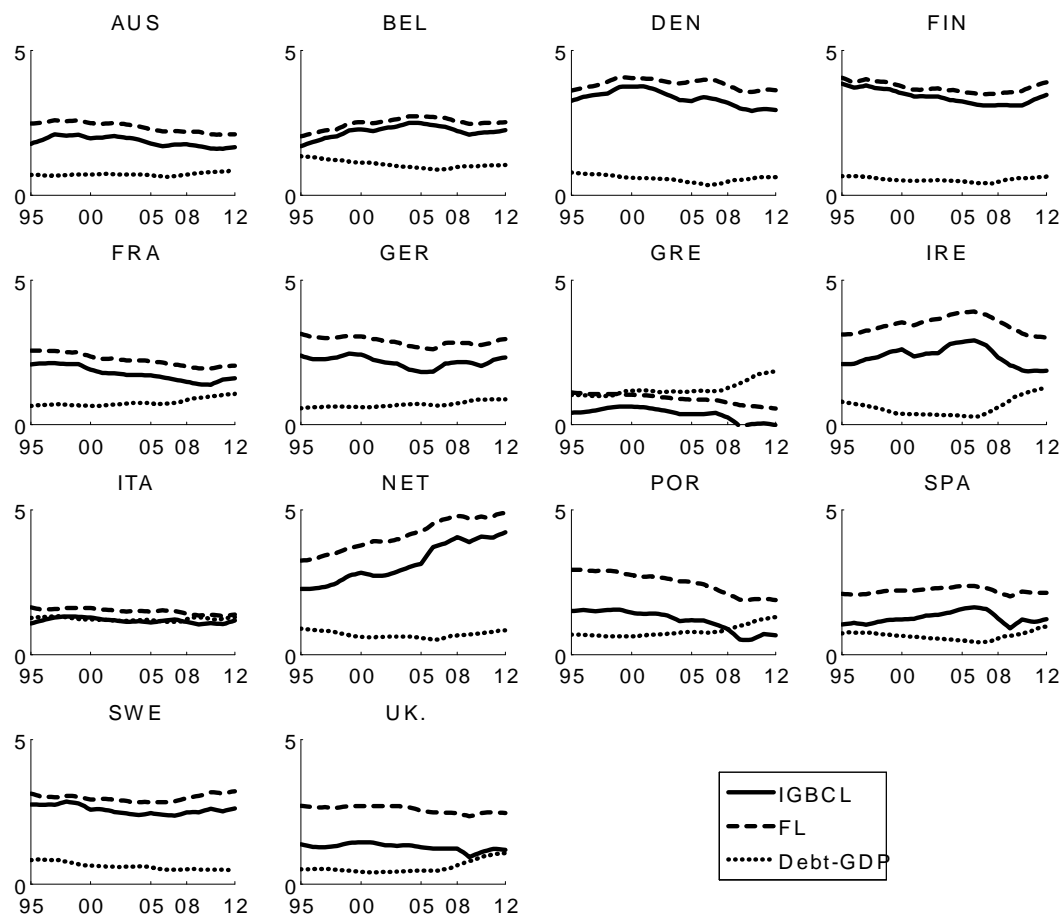
- Related literature: Davig, Leeper and Walker (2010); Trabandt and Uhlig (2011)

Debt limit (model)

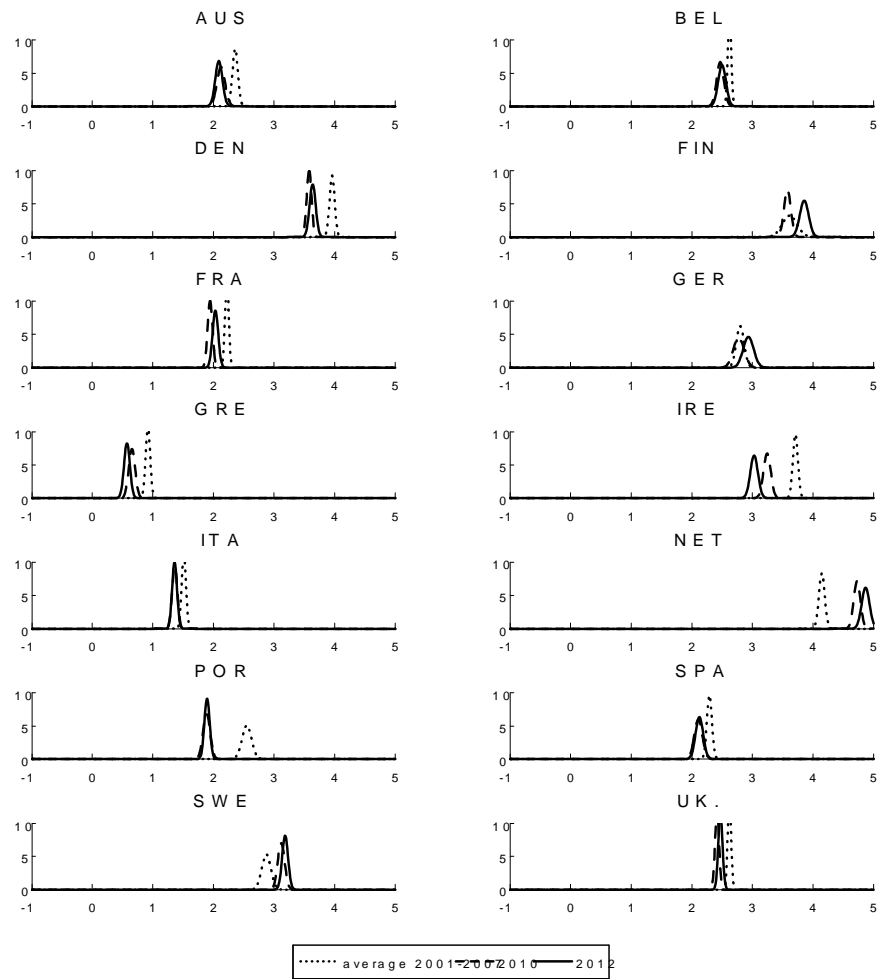
- Perturbation/projection method?
 - Monte Carlo Markov Chain algorithm
 - Based on the simulation method for solving rational expectations models
 - Judd (1998), Coleman's (1991)
 - Bi (2011) for FL in industrialized countries
- Feed in time-varying mean and volatility of (i) the ratio of government expenditures to GDP, (ii) the ratio of transfers to GDP, (iii) the shocks to technological progress and (iv) the actual tax rates
- Country-specific β



Components of the theory-based debt limits for EU14 countries, 1995:4-2012:4. All variables are as a proportion to GDP.



IGBCL, FL and debt-GDP ratio in EU14 countries, 1995:4 - 2012:4.



State-dependent probability density function of the FL of EU14 countries at selected dates.

Methodology (debt-GDP forecasts and volatility)

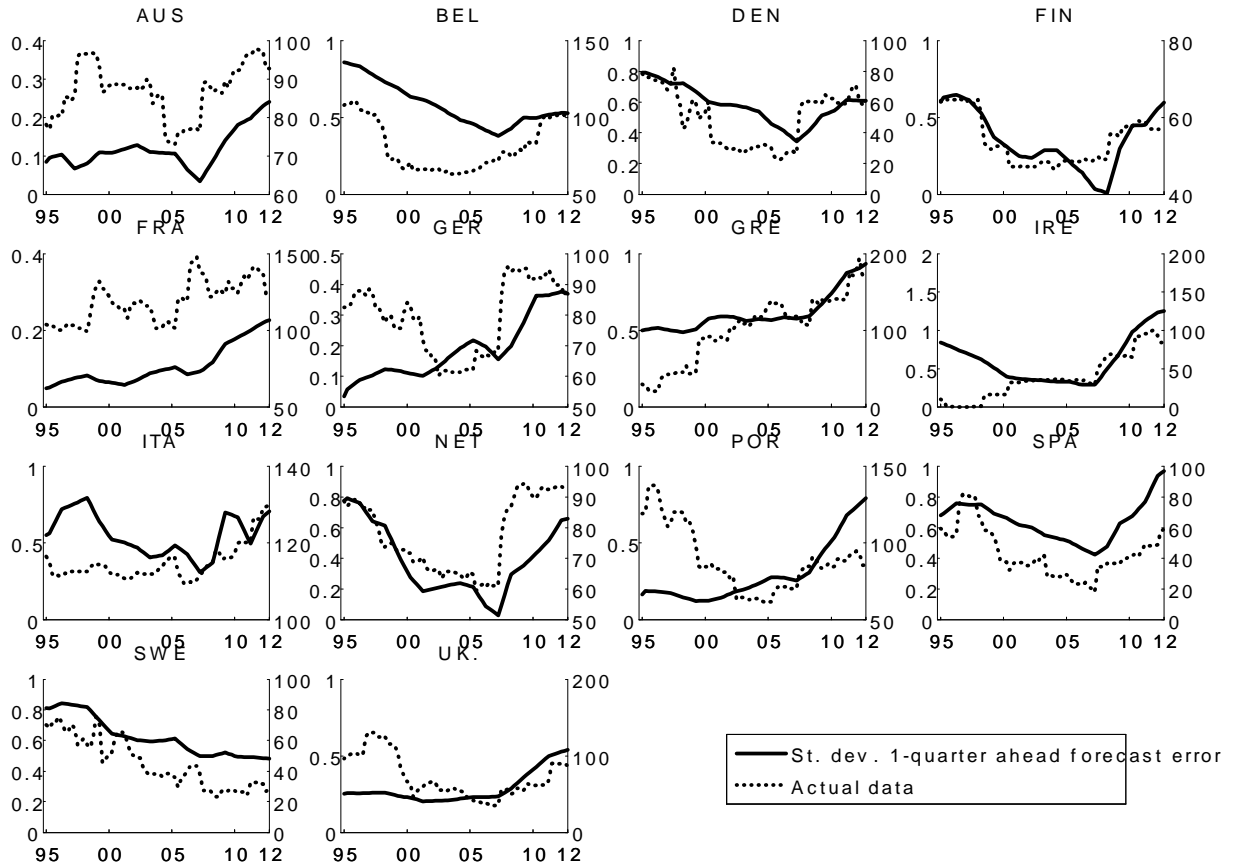
- Reduced-form VAR model
- Time-varying parameters
- Rolling-window estimation

Methodology (debt-GDP forecasts and volatility)

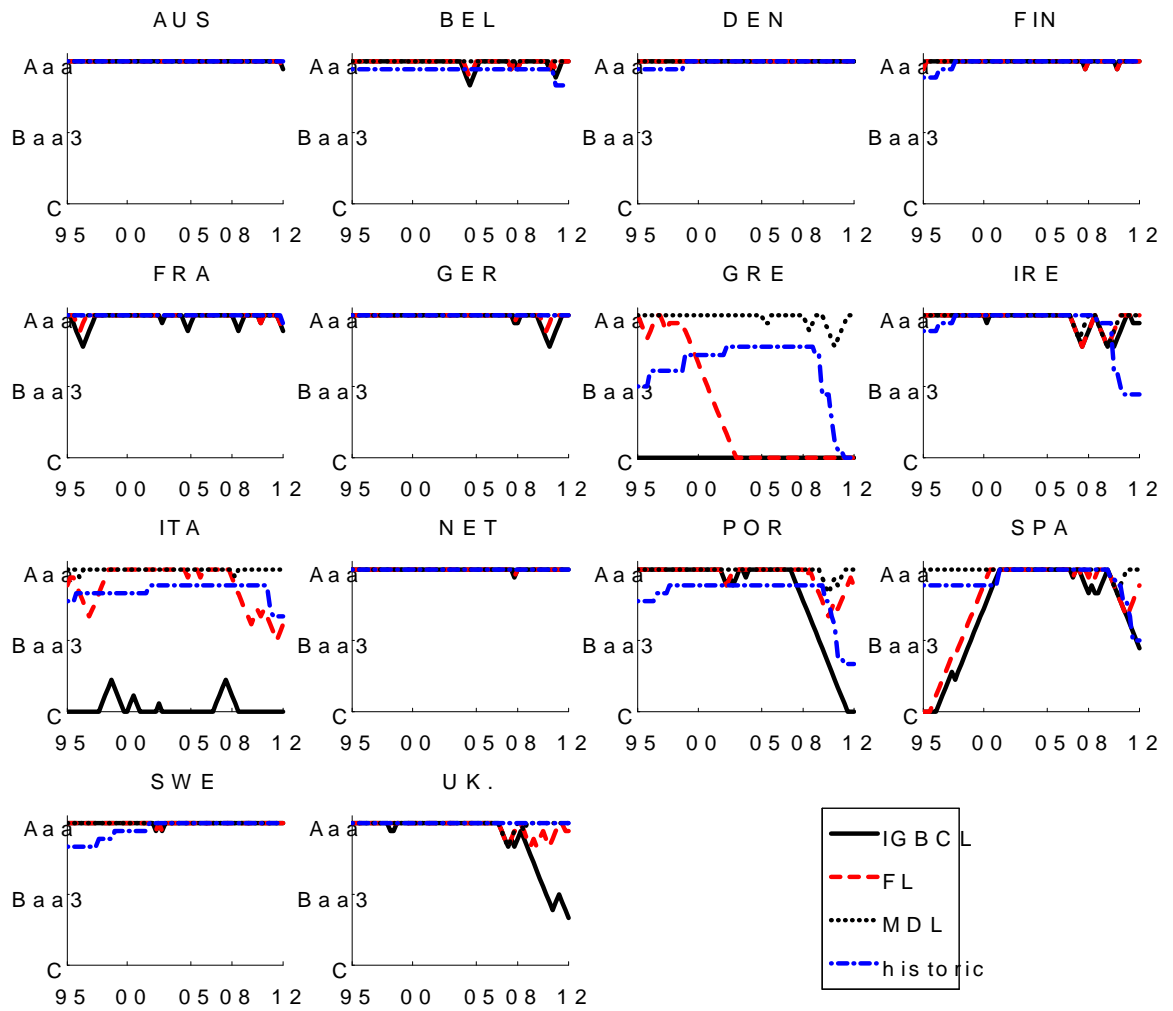
Symbol	Description	Acronyms
Country-specific variables		
$\frac{b_t}{y_t}$	Debt-GDP ratio	DEBT
$\frac{d_t}{y_t}$	Primary deficit-GDP ratio	DEF
γ_t	Growth rate real GDP	GDP
π_t	Inflation rate	INF
r_t^s	Short-term interest rate	IRS
r_t^l	Long-term interest rate	IRL
e_t	Real exchange rate depreciation	EXC
$\frac{x_t}{y_t}$	Current account-GDP	CAC
π_t^o	Oil inflation rate	OIL

Table 4: Variables included in the ROVAR model

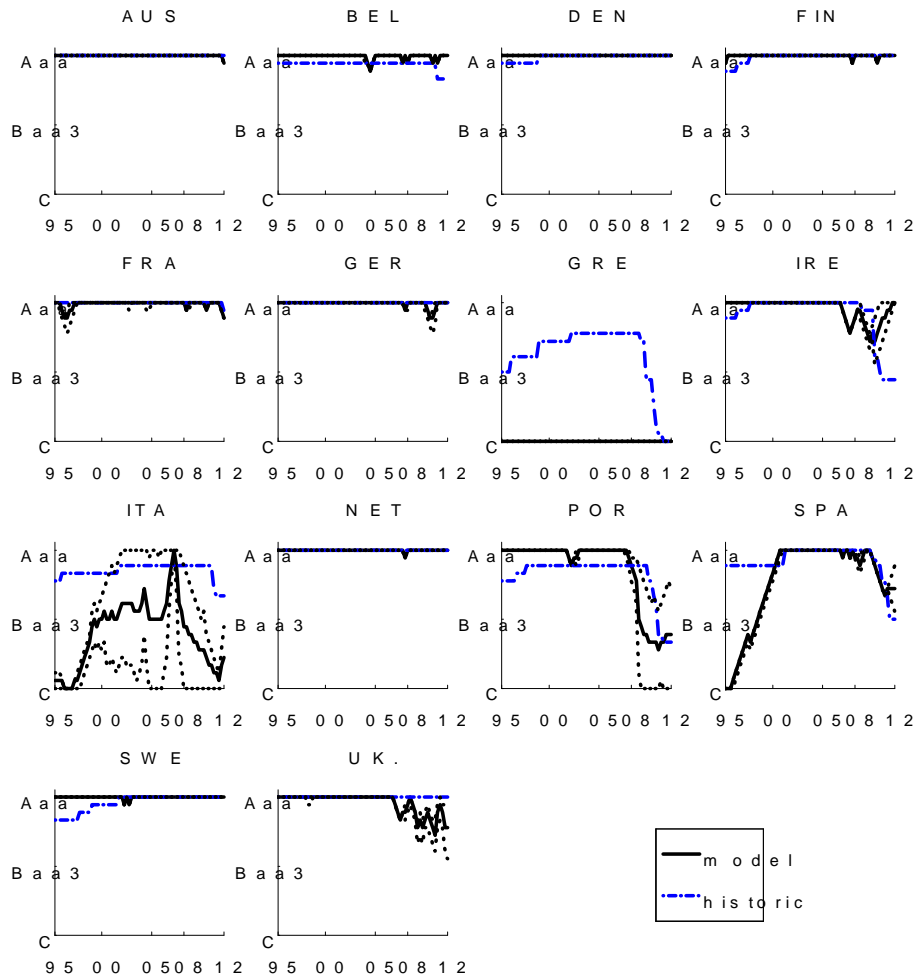
- Data: 1975:2 to 2012:4; from 1977:2 for Portugal
- Countries: AUS, BEL, DEN, FIN, FRA, GER, GRE, IRE, ITA, NET, POR, SPA, SWE, UK



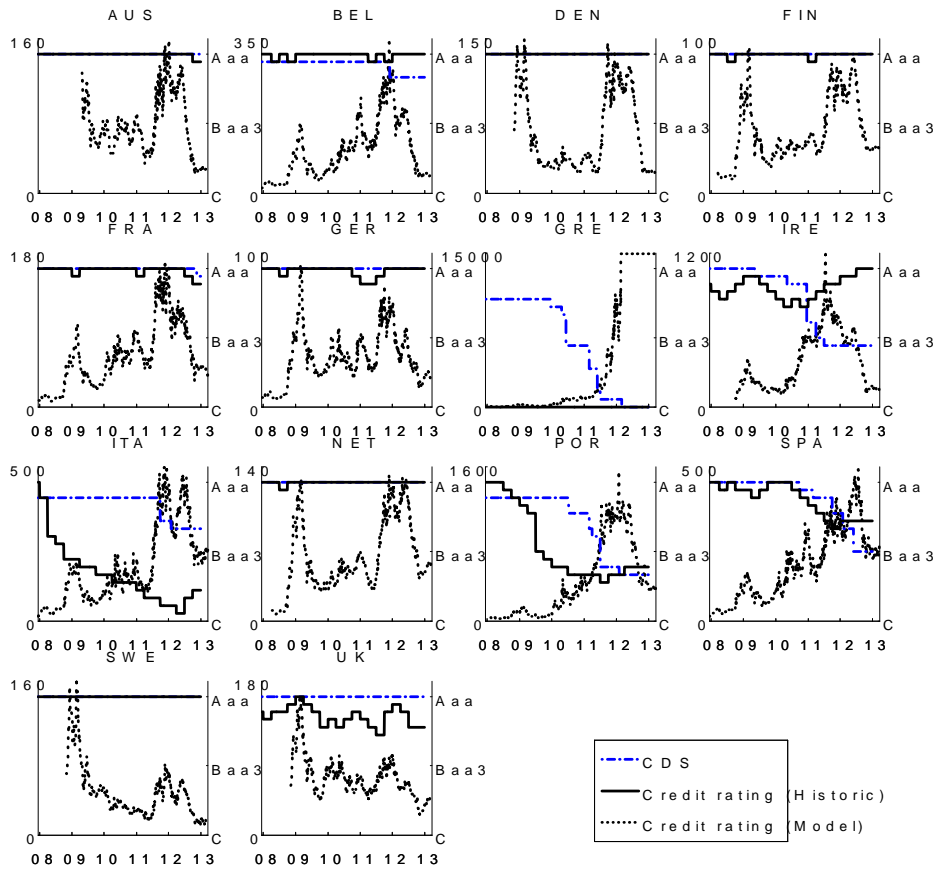
Debt-GDP ratio in EU14 countries, 1995:1-2012:4:
 actual observation (solid line) and standard deviation of
 1-period ahead forecast error (dotted line) from ROVAR
 model.



Model-based (5-year horizon) and historic credit ratings in EU14 countries, 1995:4-2012:4.



Model-based (5-year ahead) and historic credit ratings for EU14 countries, 1995:4 - 2012:4. Debt limit ranges from IGBCL to FL. Dotted lines denote confidence bands.



Sovereign credit ratings (historic and model-based) and 5-year credit default swap prices of EU14 countries, 14/12/2007 - 22/03/2013.

Table 5: Model-based and historic sovereign credit rating of EU14 countries, summary statistics.

	Average credit rating			
	Model		Historic	
	1995-2012	2008-2012	1995-2012	2008-2012
AUS	Aaa	Aaa	Aaa	Aaa
BEL	Aaa	Aaa	Aa1	Aa1
DEN	Aaa	Aaa	Aaa	Aaa
FIN	Aaa	Aaa	Aaa	Aaa
FRA	Aaa	Aaa	Aaa	Aaa
GER	Aaa	Aaa	Aaa	Aaa
GRE	C	C	Baa1	Ba1
IRE	Aa1	Aa2	Aa1	A1
ITA	Ba2	Ba3	Aa3	Aa3
NET	Aaa	Aaa	Aaa	Aaa
POR	Aa3	Baa2	Aa3	A3
SPA	A1	Aa2	Aa1	Aa2
SWE	Aaa	Aaa	Aa1	Aaa
UK	Aa1	Aa3	Aaa	Aaa
	Credit rating changes			
	Model		Historic	
	1995-2012	2008-2012	1995-2012	2008-2012
Total	168	98	40	24
Downgrades	82	61	24	24

Notes: Authors' calculations based on data in Figure 12.

Table 6: Distribution of the model-based sovereign credit rating of EU14 countries at selected dates based on the median value rating when the debt limit ranges between FL and IGBCL.

	00	05	06	07	08	09	10	11	2012
Aaa	79%	86%	86%	79%	50%	64%	50%	50%	50%
Aa	7%	0%	0%	14%	36%	7%	21%	21%	14%
A	0%	0%	0%	0%	0%	7%	7%	7%	14%
Baa	7%	7%	7%	0%	0%	0%	0%	0%	0%
Ba	0%	0%	0%	0%	7%	14%	7%	7%	7%
B	0%	0%	0%	0%	0%	0%	7%	0%	7%
C	7%	7%	7%	7%	7%	7%	7%	14%	7%
IG	93%	93%	93%	93%	86%	79%	79%	79%	79%

Notes: IG=Investment grade. Source: Authors' calculations.