Debt sustainability measures and their explanatory power for estimating government bond yields: A panel data analysis

Prepared for 390039 UK PhD-E

Econometric Methods for Panel Data with Prof. Robert Kunst

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Version June 2011

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ABSTRACT

The purpose of this article is to explain changes in sovereign yields using conventional "rating agency style" measures in comparison to contingent claims valuation-based measures. I will show that – in contrast to most conventional sovereign credit quality measures – contingent claims valuation-based credit measures have significant power in explaining the spread between 10-year sovereign yields and the expected future monetary policy rate.

The purpose of this paper is to examine the explanatory power of conventional (rating agency style) credit quality measures such as debt to GDP, debt service and debt-to-revenue ratios along with contingency claims-based credit quality measures such as overborrowing ratio, distress ratio and distance-to-distress ratio.

The impact of sovereign debt accumulation on sovereign yields has been analyzed extensively in the past several decades starting with Diamond (1965), who established an equilibrium model between debt accumulation and interest rates, and most recently by Engel and Hubbard (2005), who tested the impact of increased debt levels and deficits on the U.S. Treasury real interest rate using econometric methods.

The extension towards a cross-section of countries has been conducted for emerging market sovereign bond valuation (see, for an extensive analysis, Manasse, Roubini, & Schimmelpfennig, 2003; and Genberg & Sulstarova, 2008). However, due to the recent sovereign crisis among EMU members (Greece, Portugal and Ireland) the focus of attention has shifted increasingly to analyzing the impact of sovereign indebtedness on sovereign yields for developed markets (see Baldacci & Kumar, 2010; and Caner, Grennes, & Koehler-Geib, 2010). Older contributions exist from Alesina et al. (1992), who tested an OECD sample of countries using dynamic panel regressions, similar to the research presented here; Bernoth, von Hagen, and Schuknecht (2004) and Ardagna, Caselli, and Lane (2006).[1]

[1] A summary of cross-country studies on sovereign spreads can be found in Rowland (2004).

In all of the above research, the set of explanatory variables used was either purely macroeconomic or included only debt measures in the form of debt-to-nominal-GDP (with some exceptions, debt servicing ratios were used for emerging market sovereign bond valuation). The debt-to-nominal-GDP measure, however, is problematic, because it relates a future stock variable (debt that is paid back in the future) to a current stock variable (today's nominal GDP, not a debt duration-equivalent future nominal GDP). The sovereign 10-year yield is by definition a forward-looking market variable, and it appears plausible to assume that the relevant sovereign quality measure is either also forward-looking (i.e., uses expected debt-to-nominal-GDP) or derived from forward-looking credit-related components (e.g., present value of total debt relative to present value of future tax income). The second line of thought is the basis for considering contingent claims-based credit measures.

This paper will contribute to the existing sovereign debt-related research in three areas. First, I will test the ability of conventional "rating agency style" credit quality ratios beyond the usual debt-to-nominal-GDP metric to explain changes in sovereign yields. Second, I will extend the set of sovereign quality measures to include alternative contingent claims-based credit measures to explain changes in sovereign yields. Third, I will – in contrast to previous research – define the credit spread as a spread of 10-year sovereign bond yields against the future central bank yields, which becomes the only true risk-free rate in an environment of increasing sovereign debt.

The remainder of this paper is organized as follows. The first section describes the data sample and the data sets used for the analysis along with descriptive macroeconomic and sovereign yield statistics. It also relates some stylized facts on sovereign debt over time and across economic regions. The first section also explains the calculation of contingent claims-related sovereign credit measures and the set of control variables used for the analysis. The second section gives empirical evidence on the ability of the different tested sovereign credit measures to explain changes in sovereign yields. The third section offers conclusions and an outlook on further research that needs to be conducted.

I. The Data

A. Database Description

Interest rate data such as central bank policy rates or benchmark (i.e., sovereign) bond yields have been collected via Datastream. The same is true for all equity data used. Macroeconomic data such as real and nominal GDP and CPI were retrieved from the OECD economic outlook database. The same is true for the fiscal balances and public indebtedness data, which are all sourced from the OECD

economic outlook database. The fiscal balance and public indebtedness data for the General government (as defined by the OECD) used are:

- Gross debt interest payments
- Net debt interest payments
- General government total outlays (total outlays)
- General government current tax and non-tax receipts (total receipts)
- General government underlying primary balances (primary balance)
- General government gross financial liabilities (gross debt)
- General government net financial liabilities (net debt)

Most macroeconomic data are quarterly or annual. The quarterly data are averaged across the year for the analysis (the final data set therefore consists of pure annual data). The analysis covers 19 countries (11 EMU member states, plus Australia, Canada, Denmark, Japan, Sweden, Switzerland, the U.K. and the U.S.) between 1993 and the end of 2011. Table 1 shows summary statistics for the most relevant macroeconomic and market variables used.

Table 1: Summary statistics for major macroeconomic variables and market yields

Country	GDP growth (real)	GDP growth (nominal)	Inflation growth	Maximum primary balance	Average primary balance	Average benchmark yield (10-year)
AU	3.40	6.62	2.68	3.24	0.98	5.82
BD	1.27	2.43	1.69	3.99	-0.17	4.43
BG	1.75	3.63	1.97	6.43	3.34	4.68
CN	2.62	4.74	1.82	6.01	1.29	5.21
DK	1.63	3.69	2.04	5.95	1.83	4.82
ES	2.34	5.68	2.95	3.33	-0.57	4.97
FN	2.58	4.45	1.54	7.76	0.51	4.66
FR	1.60	3.17	1.57	1.20	-1.31	4.52
GR	2.05	7.21	4.96	3.63	-0.07	5.61
IR	3.48	7.75	2.55	6.49	-0.04	4.99
IT	0.89	3.66	2.59	6.09	2.37	4.69
JP	0.88	0.09	-0.01	-1.00	-4.60	1.57
NL	2.17	4.44	2.08	4.87	0.68	4.56
OE	1.89	3.43	1.94	2.53	-0.07	4.60
PT	1.81	4.85	2.59	0.55	-1.09	4.96
SW	1.55	2.54	0.97	2.78	-0.08	2.96
SD	2.35	4.27	1.50	5.73	0.56	4.87
UK	2.18	4.83	2.70	6.03	-1.61	4.95
US	2.53	4.71	2.41	3.93	-1.41	4.81

B. Data Construction

B.1. Conventional Sovereign Credit Measures

Several conventional and alternative credit quality measures for sovereign debt have been derived to conduct the analysis. I summarize under conventional debt measures those credit quality indicators that are usually applied by rating agencies.[2] The main indicators are:

- Debt to nominal GDP (gross) = Gross debt / Nominal GDP (DTGDPg)
- Debt to nominal GDP (net) = Net debt / Nominal GDP (DTGDPn)
- Debt service ratio (net) = Net debt interest payments / Total general government revenues (DSRn)
- Debt to revenues ratio (net) = Net debt / Total receipts (DTRRn)

Figure 1
Total (gross) debt to nominal GDP across analyzed countries

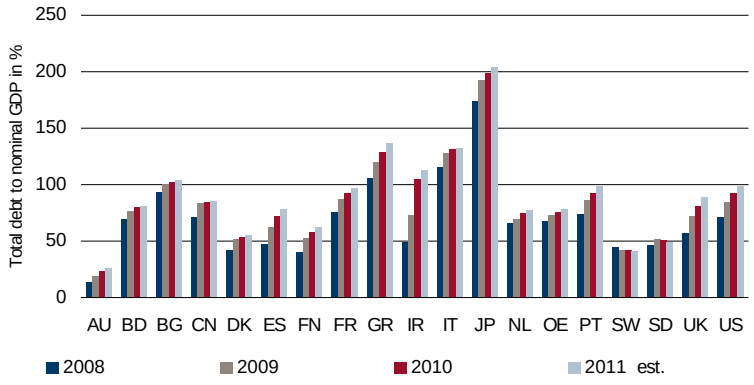


Figure 1 shows the development of total debt to nominal GDP across the tested countries. Clearly debt to nominal GDP is increasing for all analyzed countries. However, the total debt-to-nominal-GDP measure does not seem to correspond well to the recent sovereign crisis, since countries like Japan (JP), Italy (IT) and Belgium (BG) have similarly high debt levels as Greece (GR), Portugal (PT) and even France (FR) without facing serious default threats. One logical conclusion would be to take assets into consideration and correct the total (gross) debt

[2] For an overview of standard rating agency measures see Moody's (2010).

outstanding by the assets of each country resulting in the net debt figure. Figure 2 shows the net debt to nominal GDP for the tested cross-section of countries.

Figure 2

Net debt to nominal GDP across analyzed countries

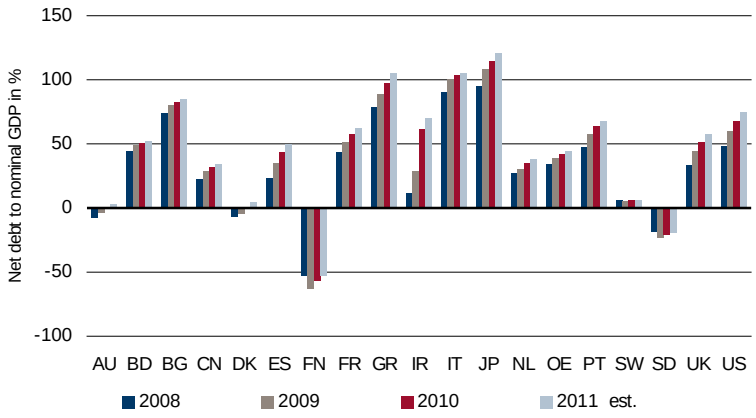


Figure 2 shows a similar picture as Figure 1. However, there are also some distinct differences, as in the case of Japan, where the inclusion of assets reduces its outstanding debt position by nearly 50%. Explanatory power remains limited, however, since only Greece is facing default, even though two other countries have similar or even higher net debt-to-nominal-GDP positions. Portugal and Ireland (IR) have even lower ratios than the U.K. or the U.S. Both sets of sovereign credit ratios shown in Figure 1 and Figure 2 are clearly unsatisfactory in explaining the default expectation dynamic today. If we aggregate the different countries into regions, a clearer picture can be obtained. Figure 3 shows the net debt to nominal GDP across economic regions.

By grouping Portugal, Italy, Ireland, Greece and Spain into one economic region (PIIGS) a better but still not satisfactory picture of the debt dynamic can be obtained. Other rating agency style measures for analyzing sovereign credit quality are shown in Figure 4 (debt service coverage ratio) and Figure 5 (net debt-to-revenue ratio).

Figure 3

Net debt to nominal GDP across regions

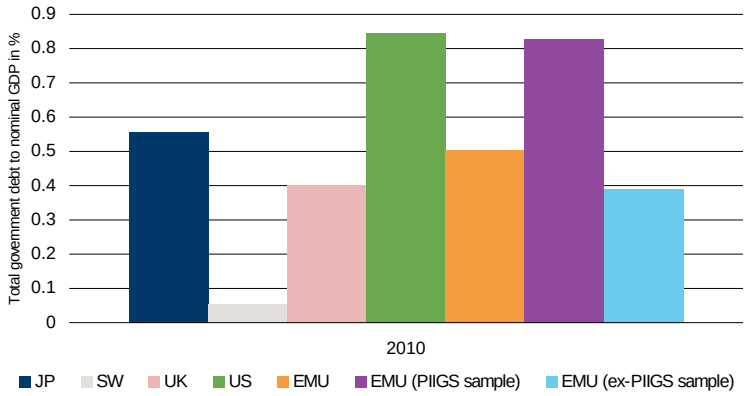
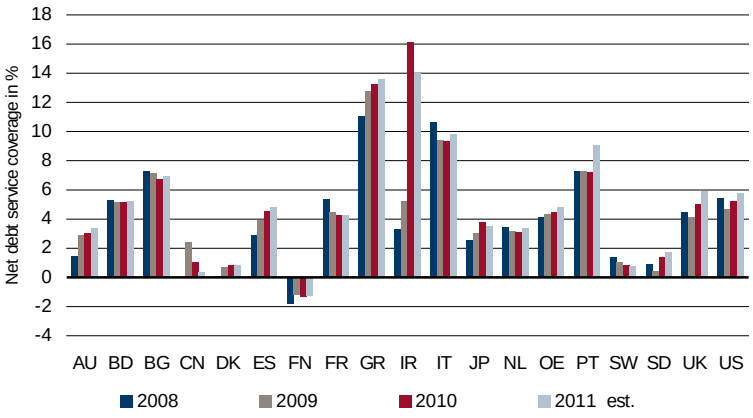


Figure 4

Debt service ratio (net) across analyzed countries



The debt service ratio seems to capture the credit dynamic better. However, one must highlight that the debt service coverage ratio's calculation is affected also by the current interest rate level that is required by the market. This is especially true if the debt is rolled over with a high frequency (low average debt duration). Hence, using debt service coverage as an explanatory variable for current sovereign yields faces serious endogeneity problems. Net debt to total revenues does not face these kinds of endogeneity problems. Here the rate of change seems to be more appropriate for explaining changes in sovereign yields than overall development level. Table 2 shows the summary statistic for the conventional sovereign debt indicators used across all analyzed countries within the sample period.

Figure 5

Debt-to-total-revenues ratio (net) across analyzed countries

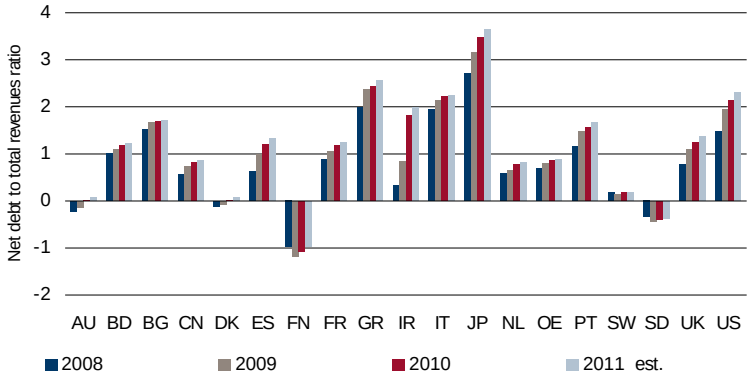


Table 2

Summary statistics for conventional sovereign debt indicators used across different countries

	AU	BD	BG	CN	DK	ES	FN	FR	GR	IR	IT	JP	NL	OE	PT	SW	SD	UK	US
Benchmark yields																			
Last observation (2011q1)	5.51	3.03	4.06	3.26	3.05	5.33	3.23	3.40	11.14	8.19	4.57	1.19	3.22	3.40	6.77	1.76	3.22	3.71	3.33
Sample mean	6.31	4.68	5.04	5.28	5.09	5.79	5.20	4.85	5.61	5.52	6.02	1.98	4.77	4.87	5.91	3.10	5.41	5.43	4.97
Sample median	5.82	4.43	4.68	5.21	4.82	4.97	4.66	4.52	5.61	4.99	4.69	1.57	4.56	4.60	4.96	2.96	4.87	4.95	4.81
Avg. rate of change	-0.11	-0.20	-0.18	-0.22	-0.25	-0.30	-0.33	-0.19	0.36	0.01	-0.39	-0.17	-0.18	-0.19	-0.13	-0.16	-0.31	-0.22	-0.14
Benchmark yields over central bank yield																			
Last observation (2011q1)	0.07	0.23	1.26	0.16	0.25	2.53	0.43	0.60	8.34	5.39	1.77	-0.03	0.42	0.60	3.97	-0.45	-0.03	0.84	0.21
Sample mean	0.97	2.04	2.38	1.86	2.26	2.56	1.96	2.07	3.13	2.23	2.68	1.59	2.05	2.23	2.62	1.72	2.28	1.34	1.81
Sample median	0.59	2.29	2.38	1.89	2.54	2.66	2.00	2.09	3.13	2.36	2.78	1.44	2.20	2.41	2.77	1.82	2.21	1.10	1.42
Avg. rate of change	-0.06	-0.16	-0.14	-0.10	-0.17	-0.05	-0.23	-0.11	0.47	0.31	-0.12	-0.17	-0.13	-0.16	0.16	-0.17	-0.13	-0.04	-0.02
Total debt to nominal GDP																			
Last observation (2011)	25.94	81.28	104.35	85.50	55.21	78.22	62.67	97.10	136.82	112.67	132.71	204.17	77.58	77.96	98.67	41.12	48.80	88.56	98.51
Sample mean	25.02	64.25	112.12	84.63	60.57	62.71	54.50	71.46	111.66	51.74	122.65	142.74	71.51	69.81	70.84	49.65	64.67	52.68	68.10
Sample median	23.58	62.18	108.41	83.39	58.25	64.31	52.59	69.97	112.03	38.73	120.93	152.28	69.36	70.81	66.78	50.25	60.23	47.40	64.21
Avg. rate of change	-0.24	1.95	-2.02	-0.60	-1.65	0.70	0.27	2.56	2.23	3.89	0.91	7.24	-1.05	0.88	5.48	-0.10	-1.63	2.21	1.48
Net debt to nominal GDP																			
Last observation (2011)	2.72	51.62	84.25	33.70	4.19	49.35	-52.34	61.78	105.12	69.69	104.74	120.44	37.72	43.92	67.58	5.95	-19.60	57.57	74.34
Sample mean	7.50	38.85	94.49	45.11	16.93	40.63	-38.04	41.19	86.69	22.27	98.05	66.89	38.53	36.77	39.69	12.15	0.52	30.30	48.19
Sample median	4.36	40.37	93.27	42.65	19.13	43.45	-38.49	41.79	86.69	13.49	98.98	72.63	36.25	36.53	35.93	12.53	0.00	27.51	44.92
Avg. rate of change	-1.00	1.85	-1.72	-1.69	-1.50	0.32	-2.02	1.94	1.51	2.11	0.23	5.74	-0.43	0.59	3.75	-0.12	-1.67	2.23	1.08
Debt service ratio (net)																			
Last observation (2011)	3.39	5.20	6.96	0.38	0.86	4.79	-1.30	4.24	13.61	13.97	9.84	3.54	3.35	4.84	9.08	0.79	1.75	5.89	5.78
Sample mean	4.82	5.73	11.79	6.24	3.18	6.99	0.42	5.36	12.81	5.31	14.57	3.72	5.81	5.20	7.31	2.24	2.90	5.70	7.13
Sample median	3.98	5.73	10.93	6.26	3.14	6.16	-0.14	5.38	12.81	3.33	12.24	3.93	4.92	5.04	7.26	2.53	3.10	5.03	6.30
Avg. rate of change	-0.24	-0.03	-0.82	-0.66	-0.33	-0.33	-0.03	-0.08	0.85	1.07	-0.91	-0.01	-0.28	-0.06	0.50	-0.07	-0.11	-0.03	-0.25
Net debt to total revenues																			
Last observation (2011)	0.08	1.21	1.72	0.86	0.08	1.34	-0.98	1.25	2.55	1.99	2.23	3.64	0.82	0.89	1.67	0.18	-0.37	1.38	2.30
Sample mean	0.22	0.87	1.94	1.06	0.30	1.06	-0.71	0.83	2.14	0.64	2.15	2.06	0.83	0.74	1.01	0.36	0.00	0.76	1.46
Sample median	0.12	0.91	1.88	1.04	0.35	1.09	-0.73	0.83	2.20	0.40	2.16	2.36	0.79	0.71	0.88	0.37	0.00	0.69	1.33
Avg. rate of change	-0.03	0.04	-0.04	-0.03	-0.03	0.02	-0.04	0.04	0.02	0.06	0.00	0.17	0.00	0.01	0.09	0.00	-0.03	0.05	0.04

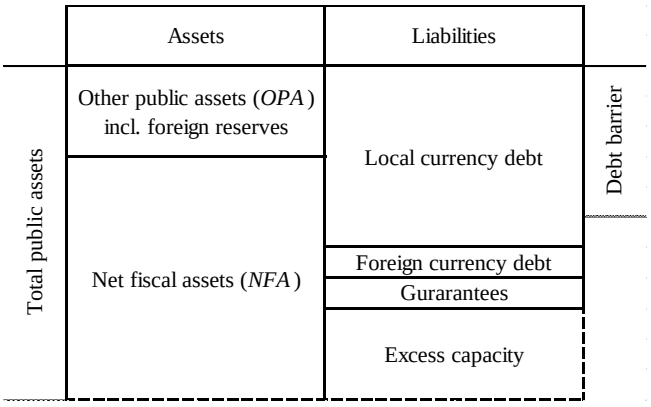
B.2. Contingent claims based sovereign credit measures

Recently more attention has been paid to alternative sovereign credit quality measures that are more closely related to the contingent claims analysis (CCA).[3] I therefore refer to these measures as contingent claims measures.

Before defining contingent claims measures, some auxiliary elements that are closely related to contingent claims analysis need to be introduced. These auxiliary variables are: other public assets (OPA), net fiscal assets (NFA) and debt barrier (DB). All of these elements are shown in Figure 6.

Figure 6

Stylized representation of the government's balance sheet



Other public assets are simply defined as the difference between general government gross and net debt.[4] The NFA component is defined as the present value of expected future primary budget surpluses discounted by the current country-specific five-year rolling average benchmark yield.[5] Since there are no data

[3] This valuation approach was inspired by Merton (1974), who used a balance sheet approach (relation between assets (equity) and liabilities) to calculate the likelihood of default for a company. For a superb summary on contingent claims for sovereign valuation see Gray, Merton and Bodie (2007). The balance sheet approach for sovereign debt has also recently been applied by rating agencies; see Moody's (2009).

[4] Based on the OECD definition, net debt is gross debt excluding financial assets of the general government sector (i.e. OPA represents financial assets in our case). Financial assets are cash, bank deposits, loans to the private sector, participation in private sector companies, holdings in public corporations and exchange rate.

[5] I use the average of 2Y, 5Y and 10Y benchmark yield to calculate the country-specific discount rate. The averaging over five years is necessary in order to reduce the risk of a possible endogeneity bias in the analysis.

available for the expected future primary budget surplus I take the maximum observed primary budget surplus for each county over the available history as expected future surplus.[6] Total public assets are the simple sum of OPA and NFA.

The contingent claims spirit becomes clearer if the debt barrier is incorporated into the analysis. The debt barrier, which in contingent claims analogy terms represents the strike price, is defined by 50% of the total outstanding long-term debt (debt maturity > 1 year) plus the current year's refinancing needs (debt that needs to be refinanced or new debt) + interest expenses payable in the current year.[7] The debt barrier will increase in cases where interest rates for financing 12M debt increase, the budget deficit increases and the percentage of debt to be rolled over in one year increases. Combinations of factors such as increasing market interest costs, increasing deficit financing needs and rolling over a high fraction of debt can create a perfect storm that bring sovereign issuers to the brink of default.

All introduced auxiliary variables allow for calculation of the following four sovereign credit quality measures that are used in the analysis:

- Overborrowing ratio = net debt / net fiscal assets (NFA)
- Debt barrier to NFA ratio = debt barrier (DB) / NFA
- Distance to distress ratio = (total public assets – debt barrier) / standard deviation of total public assets
- Default probability = 1 - cumulative distribution function of distance to distress ratio

The first three ratios over time are shown in Figure 7 to Figure 9[8]. Overborrowing ratios and debt-barrier-to-NFA ratios that are far below 1 are associated with high sovereign credit quality (close to zero default risk). The same is true for a high distance to distress ratio (high distance from the default strike price). In term of sensitivity towards changes in credit quality one can expect differences among the four introduced credit measures. Overborrowing ratios will reflect rather slow changes in credit quality, since increasing debt and changes in the overall NFA (which is affected by the change in the discount factor, i.e. the five

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[6] I am fully aware of the strong assumption that a historical maximum achieved primary balance surplus should serve expected perpetual primary surplus in the future. However, this assumption is still conservative if compared to the concept of a "maximum politically feasible primary balance" that assumes that the maximum revenues and the minimum expenditure over a rolling time period should be taken as a basis for calculating the expected perpetual primary surplus. See Moody's (2010).

[7] The debt barrier definition relies on findings by KMV (1999, 2001), Saunders and Allen (2002) and Crouhy et al. (2000). The sovereign analysis is found in Gray et al. (2007). Since historically debt refinancing volumes are not available, I will assume that, based on today's average maturity of outstanding total debt, each country in our sample refinances 20% of its total outstanding debt each year. .

[8] The graphical illustration of the default probability is omitted since it is close to zero for most of the analyzed countries.

year rolling average market refinancing rate for sovereigns) are not expected to be highly volatile. The debt barrier-based measures, however, will be more volatile, since small changes in the debt barrier will affect the ratio immediately. This is even truer for the distance to distress ratio, which includes the standard deviation of the total asset series (approximated by the standard deviation of the primary balance of each analyzed country) and the corresponding default probability.

Figure 7

Overborrowing ratio across countries (ratio greater than 1 indicates weak sovereign credit quality)

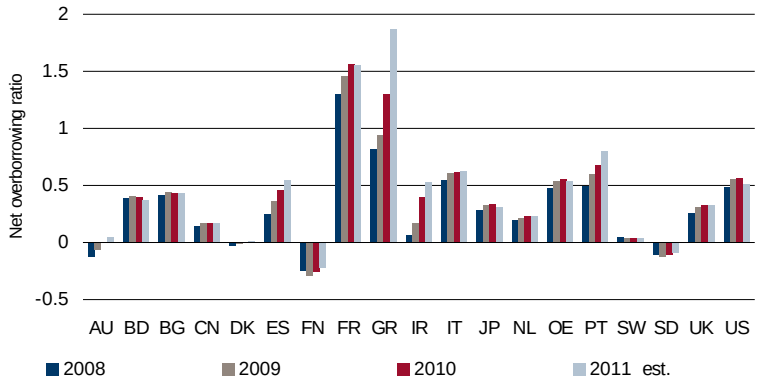


Figure 8

Debt barrier to NFA (ratio greater than 1 indicates weak sovereign credit quality)

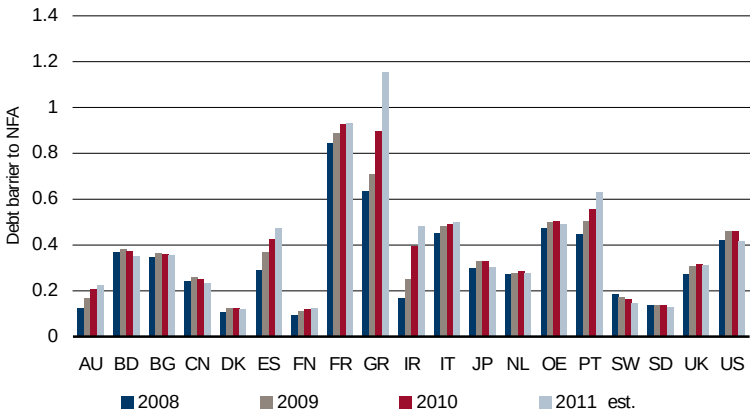
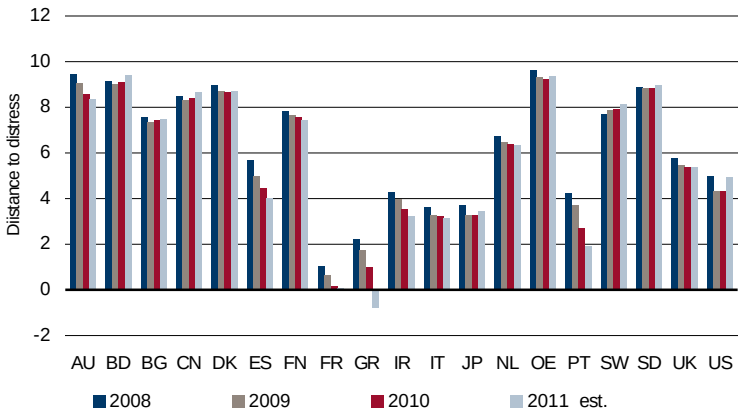


Figure 9

Debt barrier to NFA (ratio greater than 1 indicates weak sovereign credit quality)



It is worth noting that, compared to other countries, France shows exceptionally bad CCA-based credit quality measures, which is explained by its weak history of producing primary budget surpluses (see also Table 1). Table 3 shows summary statistics of all CCA-based sovereign credit measures.

Again it becomes clear that more than just credit quality measures are necessary in order to explain the current change in sovereign yields. I will therefore introduce control variables that will help to put sovereign valuation into a proper econometric framework.

B.3. Control variables

So far I have only defined sovereign credit quality measures; however, in order to explain the dynamics behind sovereign yields one needs to include a set of control variables that capture the overall dynamic of bond valuation. I have chosen the following set of bond yield control variables that fulfill the minimum criteria of tractability, comparability and sufficient history. The variables are:

- Monetary policy rate (MP): Central bank rate in real terms
- Inflation (CPI): Consumer price inflation YoY
- Business cycle (BUCYL): Real GDP growth – real central bank yield
- Risk aversion index (INVRELW): Inverse relative wealth (the inverse of the exponentially weighted wealth increase over 12M)

The first two variables are derived from monetary cycle considerations. They should mainly affect the real yield and inflation component of the average bond yield. Higher real yields and higher inflation should both increase the sovereign yield spread to expected future central bank rates. The business cycle component represents an approximation of the relative attractiveness of sovereign bonds to other fixed income assets such as investment-grade corporate or high-yield bonds. Real GDP growth usually exceeds real central bank rates in the early stages of an economic expansion (positive BCYCL). It is therefore plausible to expect that investors will move out of safe-haven assets such as government bonds into riskier assets. This should lead to a positive sign of the BUCYL coefficient since the selling pressure of sovereign bonds corresponds to higher sovereign bond yields.

The safe-haven status of several sovereign bond issuers (such as German Bunds or US-Treasuries) is captured by a risk-aversion component that approximates equity risk premium and hence general market risk aversion towards risky assets. The calculation of the risk aversion index is based on the methodology proposed by Ilmanen (1995).[9]

$$INVRELW_t = \frac{ewaW_{t-1}}{W_t} = \frac{\left(W_{t-1} + 0.9^1 \times W_{t-2} + 0.9^2 \times W_{t-3} \cdots\right) \times 0.1}{W_t}$$

This index is designed to capture the inverse of the relative wealth creation (INVRELW) of equity investments and serves as a relative risk aversion (RRA) proxy. It consists of the ratio of past to current wealth (W) where past wealth is calculated as an exponentially weighted average of wealth accumulation. The ratio is low if today's wealth position is high relative to the exponentially weighted average (ewa) of wealth accumulation over the past 12 months. In this case risk aversion is low. A low risk aversion ratio (or inverse relative wealth ratio) can intuitively be understood as an increased willingness to stay invested in risky assets due to positively experienced wealth development over time, which is especially common after a period of positive returns. A positive investment affinity toward risky assets should lead to lower sovereign bond prices (selling of safe-haven assets) and hence increase the sovereign bond yield relative to the average future central bank rate (positive coefficient). The difference between the business cycle component and the risk-aversion component is that the latter represents a jump-diffusion process while the former has a higher degree of autocorrelation and hence persistency.

[9] I follow the convention proposed by Ilmanen (1995) and use a 12-month exponentially weighted average of past wealth levels.

II. Empirical Results

A. Methodology

I have estimated four different models starting with a simple ordinary least squares (OLS) pooled regression followed by a dynamic least squares dummy variable (LSDV) panel regression with fixed time and cross-country effects. To account for the violation of the exogeneity assumption of the LSDV estimator described by Nickell (1981) – in which the lagged dependent variable will be correlated with the error term, which will lead to biased and inconsistent estimates – I will apply an instrumental variable approach (IV) using two-stage least squares (2SLS) estimation on the LSDV estimator, followed by an application of the IV-2SLS on first differences (FD), as suggested by Anderson and Hsiao (1981). The instrumental variable set is based on all exogenous variables including their one-period lag. For the FD-2SLS estimation I include the level left-hand-side variable lagged by two periods, as proposed by Arellano (1989) and Arellano and Bond (1991), as an additional instrument.

B. Results

Tables 4 and 5 show the estimated coefficients for the lagged dependent variable and the coefficients for the tested sovereign credit measures across the different applied regressions. The detailed regression results, including the coefficients for the control variables, are given in the Appendix. Nearly all coefficients for the lagged dependent variable are significantly different from zero (see Table 4). The OLS coefficients are lower than the LSDV coefficients, contrary to what should be expected given that the OLS coefficients should be biased upwards (due to the omitted variable bias) while the LSDV (within) estimator should be biased downwards (the lagged dependent variable will be correlated with the error term, leading to a downward bias in the estimated coefficient).

A plausible estimate ideally should lie between the LSDV estimate and the OLS estimate (Blundell & Bond, 1995). This ideal but not necessary constellation is not fulfilled, since all IV-based coefficient estimates are below the LSDV coefficients. However, these estimates are in nearly all cases lower than the OLS-based coefficient, therefore partially fulfilling the “ideal” constellation.

Table 3

Summary statistics for contingent claims-based sovereign debt indicators used

	AU	BD	BG	CN	DK	ES	FN	FR	GR	IR	IT	JP	NL	OE	PT	SW	SD	UK	US
Benchmark yields																			
Last observation (2011q1)	5.51	3.03	4.06	3.26	3.05	5.33	3.23	3.40	11.14	8.19	4.57	1.19	3.22	3.40	6.77	1.76	3.22	3.71	3.33
Sample mean	6.31	4.68	5.04	5.28	5.09	5.79	5.20	4.85	5.61	5.52	6.02	1.98	4.77	4.87	5.91	3.10	5.41	5.43	4.97
Sample median	5.82	4.43	4.68	5.21	4.82	4.97	4.66	4.52	5.61	4.99	4.69	1.57	4.56	4.60	4.96	2.96	4.87	4.95	4.81
Avg. rate of change	-0.11	-0.20	-0.18	-0.22	-0.25	-0.30	-0.33	-0.19	0.36	0.01	-0.39	-0.17	-0.18	-0.19	-0.13	-0.16	-0.31	-0.22	-0.14
Benchmark yields over central bank yield																			
Last observation (2011q1)	0.07	0.23	1.26	0.16	0.25	2.53	0.43	0.60	8.34	5.39	1.77	-0.03	0.42	0.60	3.97	-0.45	-0.03	0.84	0.21
Sample mean	0.97	2.04	2.38	1.86	2.26	2.56	1.96	2.07	3.13	2.23	2.68	1.59	2.05	2.23	2.62	1.72	2.28	1.34	1.81
Sample median	0.59	2.29	2.38	1.89	2.54	2.66	2.00	2.09	3.13	2.36	2.78	1.44	2.20	2.41	2.77	1.82	2.21	1.10	1.42
Avg. rate of change	-0.06	-0.16	-0.14	-0.10	-0.17	-0.05	-0.23	-0.11	0.47	0.31	-0.12	-0.17	-0.13	-0.16	0.16	-0.17	-0.13	-0.04	-0.02
Overborrowing ratio																			
Last observation (2011)	0.04	0.37	0.43	0.17	0.01	0.54	-0.23	1.56	1.87	0.53	0.62	0.31	0.23	0.54	0.80	0.04	-0.10	0.33	0.51
Sample mean	0.19	0.42	0.77	0.45	0.13	0.65	-0.20	1.62	1.07	0.17	0.85	0.26	0.40	0.70	0.48	0.07	0.07	0.28	0.60
Sample median	0.07	0.41	0.66	0.37	0.10	0.48	-0.23	1.55	0.94	0.10	0.64	0.28	0.32	0.65	0.47	0.05	0.00	0.28	0.52
Avg. rate of change	-0.03	0.00	-0.06	-0.04	-0.02	0.03	-0.01	-0.02	0.07	0.01	0.03	0.00	-0.03	-0.03	0.04	0.00	-0.02	0.00	-0.03
Debt barrier to NFA																			
Last observation (2011)	0.23	0.35	0.36	0.23	0.12	0.47	0.12	0.93	1.15	0.48	0.50	0.30	0.28	0.49	0.63	0.15	0.13	0.31	0.42
Sample mean	0.30	0.41	0.59	0.43	0.22	0.51	0.14	0.94	0.77	0.23	0.62	0.32	0.39	0.59	0.44	0.15	0.28	0.30	0.50
Sample median	0.23	0.41	0.52	0.38	0.19	0.43	0.13	0.93	0.71	0.17	0.52	0.31	0.33	0.58	0.45	0.19	0.24	0.31	0.46
Avg. rate of change	-0.02	0.00	-0.04	-0.03	-0.02	0.03	0.01	0.00	0.03	0.01	0.03	-0.01	-0.02	-0.01	0.04	0.01	-0.02	0.00	-0.02
Distance to distress ratio																			
Last observation (2011)	8.33	9.39	7.47	8.65	8.70	4.00	7.43	0.07	-0.76	3.23	3.13	3.45	6.33	9.36	1.90	8.11	8.94	5.38	4.91
Sample mean	7.34	8.43	4.08	5.00	7.53	2.77	6.43	1.36	1.54	4.09	0.72	3.96	5.80	6.96	3.35	4.76	7.13	5.33	2.92
Sample median	8.58	8.65	5.26	6.31	7.79	4.00	7.37	1.70	1.54	4.26	2.31	3.84	6.44	6.99	4.21	6.21	7.90	5.45	4.32
Avg. rate of change	0.28	0.09	0.61	0.53	0.19	0.22	0.41	-0.09	-0.23	-0.03	0.17	0.01	0.20	0.27	0.11	0.45	0.23	0.05	0.39

Table 4

Basic model specification:

$$SCBS_{it} = \alpha SCB_{it-1} + \beta_1 MP_{1t} + \beta_2 BUCYL_{2t} + \beta_3 CPI_{3t} + \beta_4 INVRELW_{4t} + \Gamma Z_{it} + \varepsilon_{it}$$

lagged dependend variable	pure macro data	Total debt to nominal GDP	Net debt to nominal GDP	Debt service coverage	net debt to revenues	overborrowing ratio	debt barrier / total public assets	default probability	distance to distress
OLS	0.6469***	0.6298***	0.6445***	0.6377***	0.6465***	0.632***	0.6193***	0.6469***	0.6292***
LSDV	0.7985***	0.7926***	0.7885***	0.7868***	0.7916***	0.7761***	0.7682***	0.7985***	0.8008***
2SLS-LSDV	0.3263**	0.3446**	0.3884***	0.3222**	0.4187***	0.1013	0.0889	-0.0773	0.547**
2SLS-FD	0.4207***	0.3761***	0.4511***	0.3599***	0.4846***	0.6492***	0.678***	0.55**	0.6568***

SCBS: Sovereign central bank spread calculated as 10-year sovereign yield minus future 4-year average central bank yield; MP: monetary policy (central bank) rate in real terms; BUCYL: business cycle indicator (real GDP growth – real central bank rate); CPI: consumer price inflation growth; INVRELW: inverse relative wealth (equity risk premium proxy); Z: represents different sovereign credit quality measures.

Table 5

Basic model specification:

$$SCBS_{it} = \alpha SCB_{it-1} + \beta_1 MP_{1t} + \beta_2 BUCYL_{2t} + \beta_3 CPI_{3t} + \beta_4 INVRELW_{4t} + \Gamma Z_{it} + \varepsilon_{it}$$

coefficients for	Total debt to nominal GDP (x100)	Net debt to nominal GDP(x100)	Debt service coverage	net debt to revenues	overborrowing ratio	debt barrier / total public assets	default probability	distance to distress
OLS	0.0055***	0.0029**	0.0188	0.1299**	0.2202**	0.5175**	0.225	-0.0335**
LSDV	0.0036	0.0039	0.0339*	0.1546	0.4174**	1.0842***	-0.1111	-0.0322*
2SLS-LSDV	0.0268**	0.0233*	0.1803***	0.9699*	4.1137***	9.8971***	12.6194	-0.8373**
2SLS-FD	-0.0006	0.0541	0.0863	3.0587*	7.4485***	13.496***	13.2619**	-1.521***

SCBS: Sovereign central bank spread calculated as 10-year sovereign yield minus future 4-year average central bank yield; MP: monetary policy (central bank) rate in real terms; BUCYL: business cycle indicator (real GDP growth – real central bank rate); CPI: consumer price inflation growth; INVRELW: inverse relative wealth (equity risk premium proxy); Z: represents different sovereign credit quality measures.

Table 5 shows that nearly all coefficients for the tested sovereign credit measures have the expected sign in all conducted test specifications. More important, however, is the level of significance for each of the tested sovereign quality credit measures. Most of the 2SLS-based estimates (the only estimates that allow inference) have significant coefficients. Among the conventional sovereign credit measures, debt-to-service coverage shows the highest level of significance and therefore justifies its predominant role within most rating agency publications. The coefficient on total debt to nominal GDP is significant in the 2SLS-LSDV framework. Based on this estimate, a 1% increase in total debt to nominal GDP is associated with a 2.7 basis point increase in the 10-year sovereign yield (assuming an unchanged average expected central bank policy rate). These estimates are very close to the results shown in Engen and Glenn (2005), which forecast the impact of higher federal debt to nominal GDP on the real 5-year forward and 10-year real yields (their estimate is around 3 basis points per 1% increase in federal debt to nominal GDP). However, using the 2SLS-FD estimator, most of the conventional sovereign credit quality measures are not significant.

The CCA-based sovereign quality measures show much stronger performance in terms of significance across different estimators. All estimated coefficients have the predicted sign and magnitude. A sovereign country that has a debt-barrier-to-total-public-asset ratio of close to or above 1 (corresponding to a full or excess utilization of the available debt capacity and hence default) pays around 10% credit compensation, which is very close to the observed yield spread of Greece to Germany at the end of Q1 2011.

Also important to notice is the increase in the estimated coefficients among the different regression methods, with IV showing a stronger sensitivity (higher coefficient) towards changing debt measures than the biased and inconsistent coefficients using conventional OLS or LSDV estimators (see Figure 10 and Figure 11).[10] Overall one can conclude that the 2SLS-FD specification (i.e. the rate of change specification) seems most reliable and points to a strong preference for CCA-based sovereign quality measures for analyzing sovereign credit quality.

[10] Note that all control variables are significant for all tested regression models, and the coefficient signs remain unaffected by the regression method chosen, indicating a certain robustness of the chosen regressors.

Figure 10

Regression coefficients for different conventional sovereign credit quality measures across various model specifications

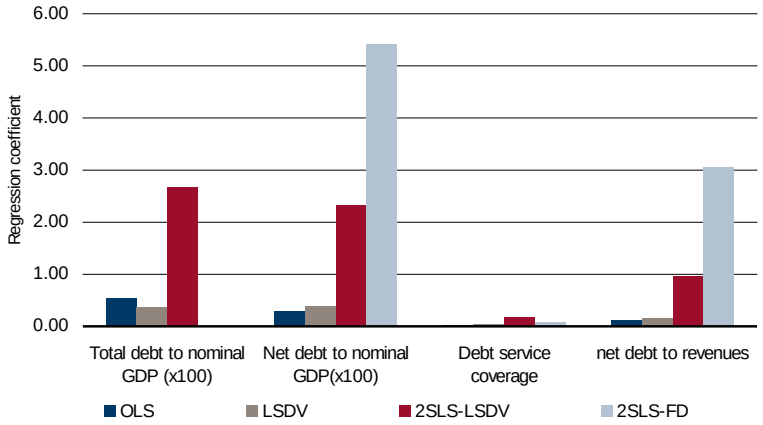
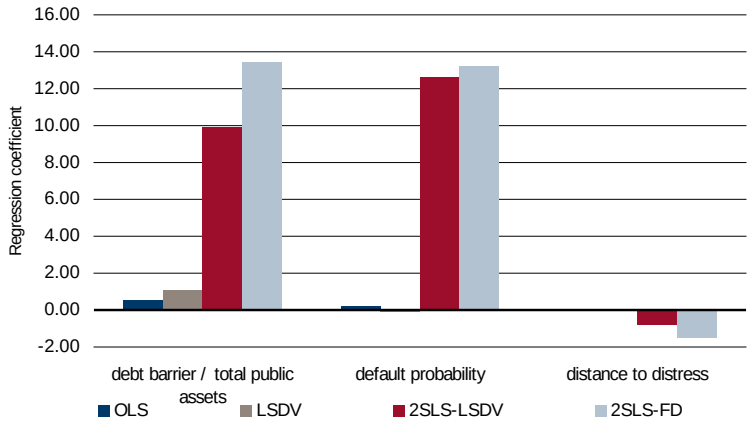


Figure 11

Regression coefficients for different contingent claims-based sovereign credit quality measures across various model specifications



III. Summary and Conclusion

In this paper I have examined the suitability of different sovereign credit quality measures for explaining changes in sovereign bond yields. I have distinguished between conventional "rating agency style" measures and contingent claims analysis-based measures. Although the conventional measures of sovereign credit quality are often found in the economic literature, their utility in explaining changes in sovereign bond yields is limited and in some cases nonexistent. Reasons for their rather poor performance can be found in the time domain, since all the conventional sovereign credit measures are calculated using today's stock or flow measures and not future stock or flow measures. Another reason is more technical and relates to the question of whether parametric models such as OLS regression are capable of replicating a market dynamic that is not reflected in the data history of the sample used. If none of the observed countries in our sample set has experienced a default, how high is the likelihood that regression models can capture the default dynamic properly?

One solution to this problem is the used of non-parametric credit valuation methods. I have therefore used contingent claims-based sovereign credit measures as explanatory variables across different econometric settings. The estimated coefficients are highly significant and robust across different regression specifications in explaining sovereign bond yield changes. All tested contingent claims based-sovereign credit quality measures have the expected sign and are of sensible magnitude.

However, further analysis is needed, especially with respect to estimating dynamic panel models. Adjusted LSDV could be employed (see Kiviet, 1995; and Bruno, 2005) along with Difference-GMM (see Arellano & Bond, 1991) and System-GMM (see Blundell & Bond, 1998) to confirm the estimated parameters. Instrument variable based-econometric techniques require an overidentification restriction test (Hansen's J test, Sargan test) to be conducted. The set of control variables can be expanded by, for example, taxation and trade factors together with tests of squared sovereign credit quality measures to capture non-linear dependencies. Last but not least, it is necessary to test whether the different sovereign quality variables should be used as expectation variables (instead of using them as calculated spot variables without lead/lag as was done in this paper). This would necessitate forecasting each of the indicators, in order to develop forward-looking measures that can be used to explain a forward-looking market variable such as the 10-year sovereign yield.

Appendix

Regression results for the spread defined as 10Y sovereign yield – future average 4Y central bank rate.

Table A-1

OLS: Dependent variable: 10-year sovereign yield - central bank rate average over four years (leading): sample (1993-2011)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Explanatory variables									
Intercept	-2.4535***	-2.7652***	-2.5247***	-2.4455***	-2.5049***	-2.5308***	-2.6457***	-2.3628***	-2.1017***
lagged dependend variable	0.6469***	0.6298***	0.6445***	0.6377***	0.6465***	0.632***	0.6193***	0.6469***	0.6292***
Real central bank rate	0.1635***	0.2002***	0.1909***	0.1649***	0.1925***	0.1769***	0.1701***	0.1635***	0.1582***
Business cycle	-0.0008	0.0031	0.0035	0.0017	0.0027	0.0006	-0.0015	-0.0008	-0.005
Headline CPI	0.2439***	0.2979***	0.2592***	0.2327***	0.2643***	0.2493***	0.2465***	0.2439***	0.242***
Risk aversion	3.2351***	3.0929***	3.253***	3.2748***	3.189***	3.361***	3.4118***	3.2351***	3.2031***
total debt/nom. GDP		0.0055***							
net debt/nom. GDP			0.0029**						
debt service coverage				0.0188					
net debt/revenues					0.1299**				
overborrowing ratio						0.2202**			
debt barrier/total public assets							0.5175**		
prob. of distress								0.225	
distance to distress									-0.0335**
debt barrier/total public assets									
distance to distress									
R2	0.6250	0.6441	0.6352	0.6302	0.6357	0.6353	0.6373	0.6275	0.6311
adj. R2	0.6196	0.6378	0.6288	0.6236	0.6293	0.6289	0.6309	0.6209	0.6245

Table A-2

LSDV: Dependent variable: 10-year sovereign yield - central bank rate average over four years (leading): sample (1993-2011)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Explanatory variables									
Intercept	-1.9681***	-2.1409***	-2.0031***	-1.9267***	-1.9946***	-1.9515***	-2.1677***	-1.8458***	-1.62***
lagged dependend variable	0.7985***	0.7926***	0.7885***	0.7868***	0.7916***	0.7761***	0.7682***	0.7985***	0.8008***
Real central bank rate	0.0862**	0.0906**	0.0889**	0.063	0.0896**	0.0916**	0.0868**	0.0862*	0.0815*
Business cycle	-0.0895***	-0.0865***	-0.0882***	-0.0901***	-0.0884***	-0.0846***	-0.0859***	-0.0895***	-0.0889***
Headline CPI	0.2288***	0.2494***	0.2491***	0.2197***	0.2508***	0.2439***	0.2419***	0.2288***	0.2324***
Risk aversion	2.3524***	2.3442***	2.3325***	2.2717***	2.3123***	2.2254***	2.179***	2.3524***	2.241***
total debt/nom. GDP		0.0036							
net debt/nom. GDP			0.0039						
debt service coverage				0.0339*					
net debt/revenues					0.1546				
overborrowing ratio						0.4174**			
debt barrier/total public assets							1.0842***		
prob. of distress								-0.1111	
distance to distress									-0.0322*
debt barrier/total public assets									
distance to distress									
R2	0.8755	0.8796	0.8797	0.8780	0.8797	0.8815	0.8841	0.8763	0.8772
adj. R2	0.8591	0.8629	0.8631	0.8610	0.8631	0.8652	0.8680	0.8591	0.8602

Table A-3

2SLS-LSDV: Dependent variable: 10-year sovereign yield - central bank rate average over four years (leading): sample (1993-2011)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Explanatory variables									
Intercept	-0.4155	-2.432*	-1.3398	-1.0971	-1.3877	-1.12	-3.3905**	-0.0098	4.327*
lagged dependend variable	0.3263**	0.3446**	0.3884***	0.3222**	0.4187***	0.1013	0.0889	-0.0773	0.547**
Real central bank rate	0.0066	-0.0164	-0.0126	-0.1045	-0.012	-0.0977	-0.1564	-0.5632	-0.1681
Business cycle	-0.1566***	-0.147***	-0.149***	-0.1456***	-0.149***	-0.1136**	-0.108**	-0.0856	-0.0816
Headline CPI	0.1989***	0.2875***	0.2733***	0.1322**	0.2856***	0.1533*	0.0954	-0.3634	0.1367
Risk aversion	2.1311**	1.8923	1.8168	1.9252**	1.7407	1.2752	1.4364	3.8433	1.1665
total debt/nom. GDP		0.0268**							
net debt/nom. GDP			0.0233*						
debt service coverage				0.1803***					
net debt/revenues					0.9699*				
overborrowing ratio						4.1137***			
debt barrier/total public assets							9.8971***		
prob. of distress								12.6194	
distance to distress									-0.8373**
debt barrier/total public assets									
distance to distress									
R2	0.8200	0.8075	0.8274	0.8120	0.8274	0.6222	0.5483	-2.2691	0.2495
adj. R2	0.7956	0.7802	0.8029	0.7852	0.8029	0.5687	0.4842	-2.7345	0.1427

Table A-4

2SLS-FD: Dependent variable: 10-year sovereign yield - central bank rate average over four years (leading): sample (1993-2011)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Explanatory variables									
Intercept	0.1041	0.0916	0.0963	0.1136	0.0866	0.22	0.2752	0.1774	0.3751
lagged dependend variable	0.4207***	0.3761***	0.4511***	0.3599***	0.4846***	0.6492***	0.678***	0.55**	0.6568***
Real central bank rate	0.6426***	0.6208***	0.6947***	0.624***	0.7254***	0.6633***	0.6654***	0.5286***	0.6722***
Business cycle	0.0087	-0.0054	-0.001	-0.0148	-0.0025	0.0401	0.0527	0.0662	0.0608
Headline CPI	0.5922***	0.597***	0.6685***	0.607***	0.7178***	0.6072***	0.6032***	0.4513***	0.6031***
Risk aversion	0.7788	0.7218	0.3805	0.6357	0.265	-0.1958	-0.438	0.3834	-0.6944
total debt/nom. GDP		-0.0006							
net debt/nom. GDP			0.0541						
debt service coverage				0.0863					
net debt/revenues					3.0587*				
overborrowing ratio						7.4485***			
debt barrier/total public assets							13.496***		
prob. of distress								13.2619**	
distance to distress									-1.521***
debt barrier/total public assets									
distance to distress									
R2	0.4890	0.5024	0.3725	0.5224	0.2670	-0.3893	-0.2811	-2.3934	-0.8401
adj. R2	0.4808	0.4926	0.3602	0.5130	0.2526	-0.4166	-0.3063	-2.4604	-0.8764

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