Fiscal Sustainability and Sovereign Risk Pricing: Evidence from Time-Varying Fiscal Reaction.

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Abstract

This paper investigates whether fiscal sustainability is priced in sovereign bond markets. For this purpose, we construct a standard measure of fiscal sustainability for 21 EU countries namely; a time-varying fiscal reaction coefficient measuring the response of the cyclically adjusted primary balance to lagged debt. Next, we examine the response of sovereign yield spreads and CDS speads to our fiscal sustainability parameter within a panel data framework. The results from static and dynamic linear panel models do not reveal statistically significant effects of fiscal sustainability on sovereign risk premia. However, nonlinear regime-switching estimations indicate significant threshold effects. In particular, fiscal sustainability exerts a significant effect on sovereign bond spreads once public debt exceeds a threshold of approximately 60% of GDP. The evidence for CDS spreads is mixed. For a subsumple of Eurozone group of countries, the threshold effect are more pronounced. Overall, the findings suggest that sovereign debt markets become more sensitive to fiscal sustainability considerations when public debt levels exceed the Maastricht threshold.

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1 Introduction

Issues regarding sovereign risk and its drivers have become highly relevant, particularly following the sovereign debt crisis in Europe and the subsequent bailout of some troubled countries by the European Central Bank and IMF. Sovereign risk pricing depends not only on debt levels but on whether fiscal authorities are perceived as willing and able to stabilize debt. Yet empirical work proxies fiscal credibility with debt-to-GDP ratios, ignoring the policy reaction that ultimately determines sustainability.

A first strand of literature examines the role of fiscal fundamentals in sovereign risk pricing and generally finds that higher debt, fiscal imbalances and a myriads of macroeconomic factors increase sovereign borrowing costs (see Bi (2012), Ardagna et al. (2007) von Hagen et al. (2011), Ghosh et. al (2013a), De Grauwe and Ji (2013), Yuan and Pongsiri (2015), Feng et al. (2026), Aizenman et al. (2011)). More recent work extends this perspective by incorporating broader measures of fiscal sustainability (for instance see Afonso et al. (2024)) and allowing for nonlinear responses (see Ciżkowicz et al (2025), Bernoth and Erdogan (2012), Ghosh et al. (2013a)). Existing evidence suggests that sovereign markets react to debt conditions. However, relatively little attention has been devoted to the exploring the concept of fiscal sustainability and its effects on sovereign risk and whether these effects could be potentially non-linear and state-dependent. The question of whether sovereign investors assess fiscal fundamentals differently when public debt reaches elevated levels is an interesting one. Indeed if debt thresholds affects investor perceptions of fiscal credibility, the relationship between fiscal sustainability and sovereign risk may be inherently nonlinear.

This paper aims to ascertain the impact of sustainable public finance on sovereign risk. Specifically, we assess if indeed the sovereign debt market reacts to the effect of fiscal sustainability proxied by a constructed time-varying fiscal parameter via a two-step procedure. Firstly, the study exploits the Bohn (1995, 1998) fiscal reaction of the primary balance to variations in the debt to GDP ratio. The intuition is that if governments increases the primary balance to offset increases or upward variations in the debt to GDP, then it pursue a stabilizing fiscal policy. We refer to the time varying coefficients of the debt parameter as a measure of fiscal sustainability and posit that the higher this parameter, the stronger is the fiscal sustainability.

The use of the debt-to-GDP ratio as a proxy for fiscal policy may provide an incomplete representation because debt is a stock variable, whereas fiscal sustainability depends on how governments respond to debt accumulation. For instance, two countries could have identical debt ratios but differ substantially in their fiscal outlook if one government systematically improves its primary balance in response to rising debt while the other does not. Consequently, debt levels alone provide an incomplete measure of fiscal sustainability because they do not capture the fiscal reaction of policymakers. Hence, this study employs a fiscal sustainability parameter derived from a Bohn-type fiscal reaction function. Unlike debt ratios, the fiscal sustainability parameter captures the extent to which fiscal policy adjusts to stabilize debt dynamics. From the perspective of sovereign investors, a high debt ratio may not necessarily imply elevated sovereign risk if fiscal authorities are expected to undertake corrective measures that ensure debt sustainability. Conversely, even moderate debt levels may raise concerns when fiscal policy appears insufficiently responsive to debt accumulation. This distinction is particularly relevant for sovereign risk pricing. Sovereign bond and CDS investors are concerned not only with the current level of indebtedness but also with the government's ability to maintain sustainable debt policies over time. As a result, fiscal sustainability measures based on fiscal reaction functions may provide additional information about fiscal credibility beyond that contained in conventional debt indicators.

As a next step, we test the impact of this fiscal sustainability parameter on the sovereign debt market proxied by two measures, namely the spread on sovereign debt and Credit Default Swaps (CDS) in a panel data framework for a group of 21 Euro Union (EU) countries using annual data. The study considered a flavor of panel data analysis models notably a linear panel model, a dynamic linear model and a non-linear regime based model with a transition variable. The findings reveals that the relationship between fiscal sustainability and sovereign risk is nonlinear and state-dependent, rather than constant across all countries and periods. We found evidence that sovereign markets appear to price fiscal sustainability in a nonlinear manner, with the effects of fiscal behavior becoming more pronounced under specific debt conditions.

This paper contributes to the literature by constructing time-varying measures of fiscal sustainability based on a fiscal reaction function using a non-parametric flexible spline model. Our paper is similar to Afonso et. al (2024) who tested a similar effect of sovereign markets to fiscal sustainability estimated from the cointegrated relationship between government revenues and expenditure. The long-run equilibrium relationship between government revenues and expenditures is grounded in theory (see Hakkio and Rush (1991), Quintos (1995), Afonso (2005)). However, in the context of sovereign debt markets, investors are more likely to assess fiscal credibility through policy reactions rather than long-run accounting identities of revenues and expenditures. Hence, we argue that the Bohn framework may offer a complementary perspective for sovereign risk analysis because it captures fiscal responses rather than long-run accounting relationships. Secondly, the relationship between fiscal sustainability and sovereign risk is allowed to vary across different debt regimes, hence, we apply a nonlinear and state-dependent model to study the relationship.

The rest of the paper is organized as follows: we begin with the methodology in section 2. Section 3 discusses the data used for the study and some stylized facts. Section 4 discusses the results of the empirical estimations. Section 5 concludes. All additional information related to the study can be found in the appendix.

2 Methodology

This section begins with the motivation for the measure of fiscal sustainability, which stems from the reaction of the primary balance to changes in the debt to GDP ration. We proceed further to discuss the construction of a time-varying fiscal sustainability parameter. Finally, the panel linear and non-linear specifications are discussed in the subsequent subsections

2.1 Fiscal reaction function

Our fiscal reaction function is according to Bohn (1995, 1998) where the primary balance is modelled as a linear function of debt and other macroeconomic control variables. Consider the accounting identity describing the accumulation of public debt in continuous time that is given by the following differential equation:

$$\dot{B}(t) = r(t)B(t) - S(t), \tag{1}$$

with $B(t) > 0$ real public debt at time t, $r(t) > 0$ the real interest rate, $S(t) \in \mathbb{R}$ the real government surplus exclusive of interest payments. A government is said to follow a sustainable debt policy if its inter-temporal budget constraint is fulfilled. In other words the present value of public debt converges to zero asymptotically. This implies that $\lim_{t\to\infty} e^{-C_1(t)}B(t) = 0$ holds, with $C_1(t) = \int_{t_0}^{t} r(\mu)d\mu$ the discount rate.

Assuming that the government in the economy determines the primary surplus to GDP ratio, $s(t) = S(t)/Y(t)$, such that it is a positive linear function of the debt to GDP ratio, $b(t) = B(t)/Y(t)$, and other variables independent of public debt, $\phi(t)$ (see Bohn (1995, 1998), Following Greiner and Fincke (2016), Afonso and Jalles (2019)), the primary surplus ratio can be written as

$$s(t) = \psi\, b(t) + \phi(t), \tag{2}$$

where ψ is the coefficient determining the response of the primary surplus to changes in public debt, relative to GDP respectively. Following Bohn (1998), fiscal sustainability is consistent with a positive fiscal reaction coefficient, indicating that governments increase primary balances in response to rising debt. The parameter $\phi(t) \in \mathbb{R}$ is represents other economic variables which affects the primary balance, such as social spending or transitory government expenditures in general, or even the business cycle which influences temporary government outlay.

2.1.1 Estimation of time varying parameter

In this paper, the fiscal reaction function in (2) is modeled according to a semi-parametric approach. We specify a time-varying coefficient model where the fiscal reaction coefficient evolves smoothly over time and estimated via penalized splines. Semi-parametric models are desirable because for the the non-parametric part, we do not have to impose restrictions regarding the functional relationship between the response variables and the explanatory variables. Rather the functional shape of the co-variate effect is derived from the datasets. Hence, we avoid model misspecification of the true data generating process.

The motivation for considering a time-varying slope hinges on two main arguments. From the macroeconomic point of view, there is empirical evidence that most long-run economic relationships are not constant but are dynamic over time (see Greiner and Fincke, (2016), Owusu et al., (2021)). This may be due to policy changes over time (for instance, fiscal and monetary polices) or technological shifts. Secondly, there is ample empirical evidence of structural breaks in most macoeconomic time series data (see

Breitung and Eickmeier (2011), Stock and Watson (2009)). Hence, modelling a time-varying slope offers robustness in the presence of evolving dynamics by accounting for the gradual or sudden changes in the data generation process.

Following Hastie and Tibshirani (1993), we consider a model of the form:

$$S(t) = \alpha + \rho(t)D(t) + Z(t) + U(t) \tag{3}$$

Where S is the response variable, The variable U represents the error term which is assumed to have a zero conditional mean and a constant variance. $\rho_(t)$ is the time varying parameter which can can be decomposed further into

$$\rho(t) = \rho + g(t) \tag{4}$$

namely, a static component ρ and a time-varying component $g(t)$. Where

$$g(t) = \sum_{i=1}^{p}(\phi_i B_i(t)) \tag{5}$$

The idea behind the above model specification is to allows the relationship between $D(t)$ and $S(t)$ to evolve over time by permitting the coefficient $\rho(t)$ to vary smoothly. The time-varying coefficient $(g(t))$ is approximated via penalized spline basis functions and estimated following Generalized Additive Models (GAMS) according to Wood (2017). Compared with alternative methods such as rolling estimation or state-space models, penalized splines allow smooth coefficient evolution without imposing parametric transition dynamics. Restricted Maximum Likelihood (REML) approach is used to estimate the smoothing parameter and thus ensures that the model fit is balanced against complexity and furthermore mitigates overfitting by penalizing excessive curvature in the model. Thus, we obtain a fiscal reaction coefficient which evolves smoothly over time.

2.2 Static and dynamic panel linear models

Our baseline panel model consists of a panel linear model of the form:

$$\mathbf{y}_{it} = \mu_i + \lambda_t + \beta\mathbf{X}_{it} + \phi_j \sum_{j=1}^{N} \mathbf{S}_{it}^{j} + \mathbf{e}_{it} \tag{6}$$

where $\mathbf{y}_{it}$ is the dependent variable (Sovereign spread), μ_i represents the individual fixed effects, λ_t represents the time effects, $\mathbf{X}_{it}$ is the co-variate of interest (fiscal parameter) while β measures the impact of the fiscal parameter on the Sovereign spread variable. S_{it} represents all other variables that explain the Sovereign spread and have therefore been controlled for. ϕ's, on the other hand, measure the impact of the controls on the Sovereign spread. $\mathbf{e}_{it}$ represents the idiosyncratic errors which are assumed to be independent and identically distributed (i.i.d).

Next, we consider a dynamic model where a lagged dependent variable to added to the regressors to capture the inertia behaviour (persistence) of the sovereign spreads if they appear statistically significant.

$$\mathbf{y}_{it} = \mu_i + \lambda_t + \beta_1 \mathbf{y}_{i,t-1} + \beta_2 \mathbf{X}_{it} + \phi_j \sum_{j=1}^{N} \mathbf{S}_{it}^{j} + \mathbf{e}_{it} \tag{7}$$

(7) is dynamic due to the inclusion of the lagged dependent variable. Such a dynamic model is characterised by the evidence of persistent autocorrelation. We use a dynamic model to capture the potential persistence or inertia behaviour of debt yields and also deal with potential endogeneity emanating from the presence of the regressors. We apply the panel GMM estimator by Blundell and Bond (1998) to address potential endogeneity issues, utilising lags of the variables and lags of the first differences, respectively, as potential instruments for the model.

2.3 Regime dependent panel model

Next, we extend the linear model to allow for the possibility of conditioning the model on multiple debt regimes. We therefore resort to the Panel Smooth Transition Regression (PSTR) model according to Gonzalez et al. (2017). A two regime PSTR is specified as

$$y_{it} = \mu_i + \lambda_t + \beta_0 x_{it} + \beta_1 x_{it} g(w_{it}; \gamma, c) + u_{it} \tag{8}$$

The function $g(w_{it}; \gamma, c)$ is the transition function which is observable, continuous and bounded. The variable w_{it} is the transitional variable on which the regime switching is conditioned, c is a vector of location parameter whilst γ measures the slope of the transition function. The transition function is modelled by a logistic regression function (see Teräsvirta, 1994 and 1998) and bounded between 0 and 1 as per below

$$g(w_{it}; \gamma, c) = (1 + exp(-\gamma \prod_{j=1}^{r}(w_{it} - c_j))^{-1} \tag{9}$$

where $\lambda > 0$ determines the smoothness of the transition between the regimes. The location parameter c captures the threshold between the two extreme regimes with transition functions $g(w_{it}; \gamma, c) = 0$ and $g(w_{it}; \gamma, c) = 1$. The index r determines the number of regimes and could be more than one depending on the variations in the parameter. For instance when $r = 1$, the model is characterised by two extreme regimes associated with high and low values of the transition variable (w_{it}). In that case the coefficients from equation 1 switches between β_0 and $\beta_0 + \beta_1$ and the change is centered around c_1. When $r = 2$ the transition function attains its minimum at $(c_1 + c_2)/2$ and attains its maximum at 1 for both low and high values of w_{it}. The determination of the number of regimes, and the formal tests for nonlinearity are discussed in the estimation section.

3 Data

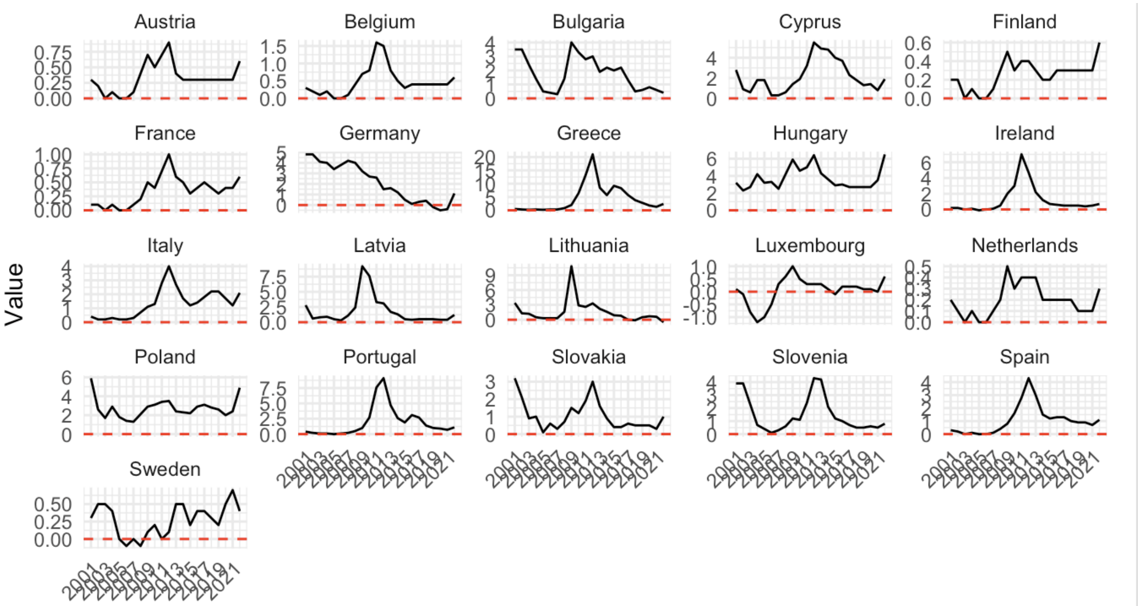
The data used for this empirical study is made of annual macroeconomic information for 21 selected Euro Area countries spanning from 2001 until 2022. The selection of the countries is based on the availability of data. The countries include Austria, Belgium, Bulgaria, Cyprus, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain and Sweden. The proxy for sovereign credit risk (spread) is the difference between the 10-year yield on government bonds and the 10-year yield on German government bonds, which are usually considered risk-free for the 20 EU countries. In the case of Germany, we used 10-year yield on US government bond. Sovereign yield data is sourced from the US Federal Reserve Bank St. Louis (2025). As an alternative measure of sovereign credit risk, we use the Credit Default Swaps. Following Aizenman et al. (2011), we use the 5-year maturity since they argued that it is the deepest and most actively traded CDS market. Due to unavailability of CDS for earlier years, the uniform series starts from 2006. Our measure of fiscal sustainability is the fiscal parameter discussed in Section 2, which is a time-varying parameter that measures the slope of the relationship between the primary balance and the debt. In order to get reliable estimates, we go back in time to obtain more observations beginning from 1993. The stronger the slope parameter, the stronger the upward adjustment of primary balance in response to increases in debt to GDP ratio and hence an indicator of prudent public finance. The control variables are chosen according to Ghost et al (2013) and Afonso (2024). We control for international trade by including the current account balance which is a percentage of GDP ratio. To account for the state of the economy, we control for the growth of GDP. In other to account for the effect of the business cycle, we include the output gap in the model. Next, we control for inflation proxied by the changes in the consumer price index. Finally we account for the effect of major episodes of financial and economic instability on sovereign risk pricing, we construct dummy variables for the Global Financial Crisis, the European Sovereign Debt Crisis, and the COVID-19 pandemic. A detailed description and source of our dataset ccan be found in Table 8.

Figure 1 presents a country-wise line plot of the sovereign spread (panel a) and CDS (panel b). With respect to panel (a), it can be observed that for most of the countries, the spreads peaked during the EU debt crisis period between 2011 until 2013 and then declined steadily thereafter. The CDS plots (Panel b) reveal an even more dramatic response during the Eurozone crisis. Greece stands out, with CDS spreads reaching extraordinary levels, while Portugal, Ireland, Italy, Spain, Cyprus, and Hungary also experienced substantial increases. Overall, the CDS market appears to react more strongly to episodes of financial distress than sovereign bond spreads, reflecting heightened concerns regarding sovereign default risk during the Eurozone debt crisis. Two points are worth noting from the graphs. Firstly, it is evident that sovereign debt crisis effects are likely significant determinants of sovereign spreads and CDS. Secondly, market pricing of risk may likely differ between normal economic periods and fiscal or financial stress periods.

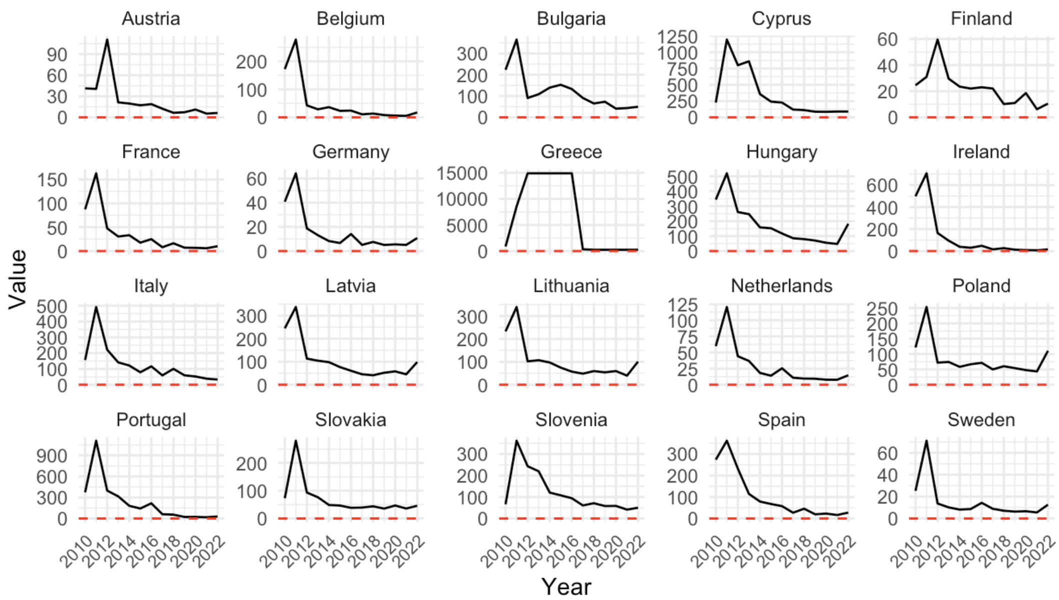
4 Empirical results

As discussed earlier, the empirical estimation is a two-step procedure. Firstly, we estimate a time varying sustainability parameter after which we utilize this parameter in a panel regression. Recall that (3) (4) and (5) depicts the fiscal reaction function of the primary balance explained by lagged debt and other macroeconomic variables. As discussed in section 2.1.1, we used penalized splines to estimate and obtain the time varying parameter after controlling for the business cycle (output gap). The time-varying fiscal sustainability

Figure 1: Country-wise plots



(a) Sovereign spreads



(b) CDS

parameter is estimated separately for each country. Figure 2 presents the evolution of the country-specific fiscal sustainability parameter and compares it with the corresponding debt-to-GDP ratio over time. There exists cross-country heterogeneity in the sustainability parameter in that countries such as Germany, Latvia, Luxembourg, Greece, and France have positive values on average. On the other hand Poland, Bulgaria, Poland, Cyprus, Hungary, Netherlands, Slovakia, Slovenia and Sweden exhibit negative fiscal sustainability parameters on average. In the case of Sweden, we observe that both the debt and the estimated fiscal sustainability parameter are declining together. One possible interpretation is that lower debt levels reduced the need for active fiscal adjustment, resulting in weaker estimated fiscal responses despite relatively stable debt conditions. Overall, we have seen from Figure 2 that governments differ considerably in their responsiveness of primary balances adjustments to changes in public debt. Secondly, the declining nature of the time varying fiscal adjustment parameter even as debt rises for some of the countries notably Austria, Belgium, Bulgaria, Ireland, Portugal, Greece and Spain suggests declining fiscal response and reminisces the concept of fiscal fatigue according to Ghosh et al (2013b).

Figure 2: Fiscal sus. parameter and Debt (ratio of GDP)

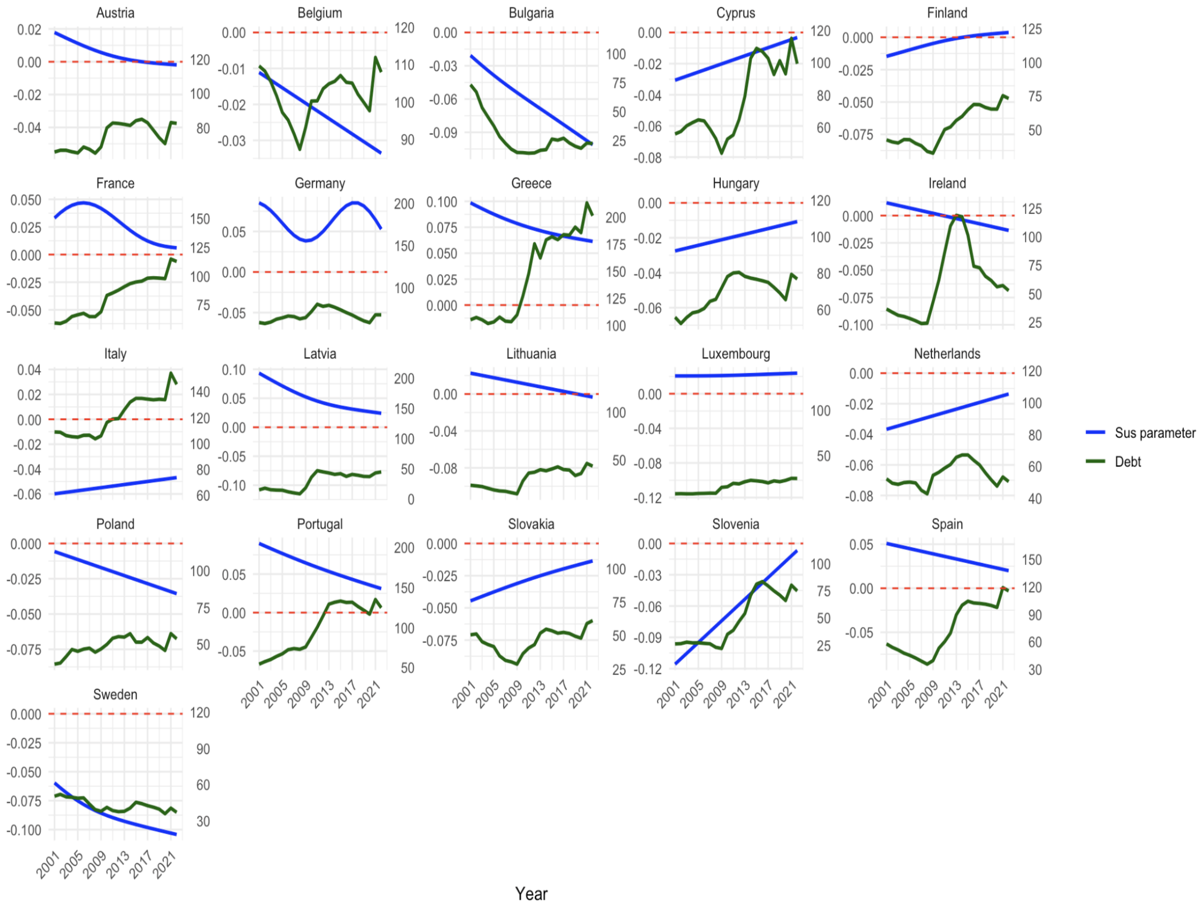


Table 1: Fiscal sustainability parameter by country

Country	Mean	Median	SD	Min	q25	q75	Max
Austria	0.00498	0.00302	0.00626	-0.00191	-0.000300	0.00933	0.0178
Belgium	-0.0223	-0.0223	0.00694	-0.0336	-0.0280	-0.0167	-0.0111
Bulgaria	-0.0625	-0.0633	0.0244	-0.101	-0.0821	-0.0436	-0.0207
Cyprus	-0.0169	-0.0169	0.00847	-0.0306	-0.0238	-0.0101	-0.00323
Finland	-0.00354	-0.00218	0.00592	-0.0147	-0.00807	0.00157	0.00371
France	0.0281	0.0317	0.0152	0.00609	0.0130	0.0418	0.0468
Germany	0.0639	0.0658	0.0166	0.0383	0.0505	0.0800	0.0852
Greece	0.0763	0.0741	0.0115	0.0614	0.0667	0.0846	0.0985
Hungary	-0.0191	-0.0191	0.00518	-0.0275	-0.0233	-0.0149	-0.0107
Ireland	-0.000937	-0.000937	0.00780	-0.0135	-0.00724	0.00537	0.0117
Italy	-0.0534	-0.0534	0.00403	-0.0599	-0.0566	-0.0501	-0.0469
Latvia	0.0497	0.0436	0.0217	0.0241	0.0317	0.0649	0.0934
Lithuania	0.00963	0.00963	0.00802	-0.00334	0.00315	0.0161	0.0226
Luxembourg	0.0217	0.0214	0.00109	0.0206	0.0207	0.0225	0.0238
Netherlands	-0.0252	-0.0252	0.00713	-0.0367	-0.0309	-0.0194	-0.0136
Poland	-0.0207	-0.0207	0.00923	-0.0356	-0.0281	-0.0132	-0.00573
Portugal	0.0587	0.0575	0.0181	0.0312	0.0438	0.0729	0.0898
Slovakia	-0.0279	-0.0272	0.00961	-0.0445	-0.0355	-0.0200	-0.0136
Slovenia	-0.0612	-0.0612	0.0317	-0.116	-0.0884	-0.0339	-0.00668
Spain	0.0354	0.0354	0.00954	0.0200	0.0277	0.0431	0.0509
Sweden	-0.0874	-0.0904	0.0132	-0.104	-0.0978	-0.0789	-0.0596

In table 6 in the appendix, the summary statistics of the dataset is presented. It can be observed that the debt variable has the most variability (in terms of the standard deviation) and hence, depicts a high level of heterogeneity among the countries whilst the fiscal sustainability parameter has low variability comparably.

Before we begin with our estimations, we conduct a panel stationarity test for all variables as given by table 7 in the appendix employing the Im Peseran and Shin (IPS) test as well as the Levin, Lin and Chu (LLC) tests. This is to ensure our regression results does not emanate from a spurious regression. All variables appears stationary according to the two test with the exception of lagged debt and the fiscal parameter. The IPS tests infers stationarity for the sustainability parameter whilst LLC infers stationarity of the lagged debt parameter. We therefore proceed to use all variables in our model.

To ascertain the impact of the fiscal stance on sovereign risk, we estimate (6), a static panel data fixed effect model and (7) a dynamic fixed effect model. The Hypothesis from the Hausmann test is used to determined the appropriateness between the fixed and random effects. From table 9, it can been observed that the null hypothesis of no correlation between the individual effects and the regressors is rejected. Hence a fixed effect model is more appropriate for the panel data. We regress the sovereign spread and CDS on the fiscal sustainability parameter and control for other economic variables as presented in table 2. The sovereign spread is the dependent variable for the panel on the left whilst the CDS is the dependent variable for the panel on the right. We considered two model specification; namely a model with only individual effect and a model with both individual and time effects where we take different crisis situation also into consideration. Beginning with the sovereign spread as the dependent variable, it can be observed that the lagged debt variable is mainly statistically significant whereas the fiscal sustainability parameter is not. The same is observed when we consider the dynamic GMM estimates where the debt estimate is only significant when we consider the full model specification (Mod III), however with a negative sign. Fiscal sustainability is not statistically significant in all model specification (mod I to Mod IV). The linear results suggest that sovereign investors likely respond primarily to debt levels rather than fiscal sustainability measures.

Regarding the control variables, it can be observed that GDP growth has a negative statistically relationship which implies economic growth reduces sovereign spread and the results is robust for all four specifications. Inflation on the other hand affects sovereign risk positively in that as inflation rises, sovereign spread increases. A positive output gap reduces sovereign spread in the case of static model however, this effect disappears in the case of the dynamic estimation. Accounting for time effects and for that matter crisis, we observed it does not materially change the estimated coefficients of the main explanatory variables. In particular, the fiscal sustainability parameter remains statistically insignificant, while the effects of debt, GDP growth and inflation remain broadly unchanged. This suggests that the results are not only driven by common shocks affecting all countries simultaneously, such as changes in global financial conditions.

The results does not appear to be different if we consider CDS as the dependent variable from the right hand panel. Once again fiscal sustainability does not appear statistically significant for all model specifications (Mod V to Mod VIII) irrespective of whether the model is static or dynamic. This finding suggests that fiscal sustainability does not exert a uniform average effect on sovereign default risk in linear specifications. Laggeddebt however appears negative and statistically significant which appears counterintuitive because one might expect higher debt to increase sovereign risk. A possible explanation could be that some countries with higher debt in the sample may be countries that benefited from institutional support mechanisms or pursued stronger fiscal adjustment programs which lowered perceived default risk over time. Our findings differ from Afonso et al. (2024) who found a consistently negative effect of fiscal sustainability on CDS and CDS spread for quarterly data suggesting that an improvement in fiscal sustainability reduces sovereign risk. However, their construction of sustainability stems from a time-varying cointegration relationship between public revenue and public expenditure. Secondly their estimated was based on static linear models only. This study measures fiscal sustainability through a time-varying Bohn-type fiscal reaction parameter and additionally considers dynamic specifications that account for persistence in sovereign risk. Inflation has a positive significant effect in the static linear model but disappears in the dynamic estimations especially once time effects are controlled for. The effects of GDP growth similarly disappears once time effects are controlled for both in the dynamic and static framework. Summarising our results from table 2, the linear panel estimates provide little to no evidence that sovereign spreads respond systematically to fiscal sustainability. Additionally, the efffect of laggeddebt variable is mixed depending on the specific dependent variable (Sovereign spread or CDS) and type of specifiction (static or dynamic models)

We further estimate the model for the euro area subsample to assess whether the baseline results are driven by the common monetary and institutional framework of the monetary union. Unfortunately a separate analysis for non-euro area countries is not pursued because the subsample for non-euro area contains only four countries, resulting in a very limited cross-sectional dimension and insufficient observations to support reliable panel estimation.

Table 2: Panel Fixed Effects and Dynamic Panel GMM Estimates

	Sovereign Spread				***CDS***			
	FE		GMM		FE		GMM	
Variables	Mod I	Mod II	Mod III	Mod IV	Mod V	Mod VI	Mod VII	Mod VIII
Lagged dependent variable			0.7782***	0.7123***			-0.1690	-0.3952**
			(0.0769)	(0.1455)			(0.1049)	(0.1824)
Fiscal parameter (β)	-0.0380	-0.0613	0.0041	0.0006	-0.0048	-0.0034	-0.0038	-0.0230
	(0.0252)	(0.0472)	(0.0115)	(0.0168)	(0.0485)	(0.0488)	(0.0289)	(0.0781)
Lagged debt	0.0206***	0.0238***	0.0024	-0.0841***	-0.0167***	-0.0163***	-0.0167***	-0.0039**
	(0.0048)	(0.0043)	(0.0117)	(0.0299)	(0.0044)	(0.0044)	(0.0044)	(0.0018)
Current Account (% GDP).	0.0029	0.0033	-0.0169	-0.0128	-0.0203	-0.0239	-0.0191	-0.0279
	(0.0215)	(0.0194)	(0.0126)	(0.0157)	(0.0151)	(0.0153)	(0.0122)	(0.0282)
GDP Growth cap.	-0.1609***	-0.1500***	-0.1076***	-0.1155***	-0.0004	0.0016	-0.0369**	-0.0245
	(0.0225)	(0.0208)	(0.0327)	(0.0425)	(0.0161)	(0.0162)	(0.0115)	(0.0163)
Inflation	0.1035***	0.0988***	0.1113***	0.1259***	0.0597**	0.0584***	0.0463**	0.0632
	(0.0329)	(0.0297)	(0.0403)	(0.0341)	(0.0176)	(0.0177)	(0.0203)	(0.0434)
Output gap	-0.0963***	-0.0898***	0.0262	0.0371	0.0072	0.0081	0.0358**	0.0243
	(0.0256)	(0.0237)	(0.0321)	(0.0356)	(0.0183)	(0.0185)	(0.0173)	(0.0320)
Banking Crisis		0.1447		-0.7614		0.5410		3.8201
		(0.3412)		(0.8626)		(0.3825)		(2.3232)
Sovereign Debt Crisis		7.7676		10.4295***		0.4203		2.4385
		(0.9904)		(3.8255)		(0.4815)		(2.7776)
Covid Crisis		-1.3017***		-0.2791		0.0274		0.2345
		(0.2247)		(0.3064)		(0.1110)		(0.3064)
Sargan Test			15.08(0.9)	10.48(0.9)			18.09(0.9)	16.16(0.9)
Auto. test 2			-1.314(0.18)	-1.45(0.14)			0.42(0.67)	-0.76(0.44)
Wald test coeff.			809.17(0.00)	1222.75(0.00)			119.27(0.00)	114.09(0.00)
Observ	462	462	462	462	260	260	260	260
Num. observ used			861	861			460	460
Indiv effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	No	Yes	No	Yes	No	Yes	No	Yes

Standard errors are indicated in parentheses. *, ** and *** indicate statistical significance at 10%, 5% and 1% respectively. Standard errors are based on HAC scheme (static model) and a two-step weighting matrix (GMM). Hence they are robust against autocorrelation and heteroskedasticity. The GMM instruments used are as follows: Mod I to Mod III - 5 lags of the sovereign spread, 1 lag of inflation, 1 lag of the fiscal parameter, 1 lag of investment, 1 lag of current account, 1 lag of debt and 1 lag of GDP growth rate

Table 3 presents the results for the Eurozone sample. It can be observed that the results are not so different from the full sample results in table 2. Fiscal sustainability does not appear to exert a statistically significant average linear effect on sovereign spreads in the Euro area irrespective of whether we consider a static or dynamic model. Laggeddebt is only significant in the static model and not significant in the dynamic specification and hence not robust. Once again GDP growth is statistically significant with the expected signs and robust across the four model specifications (Mod I to Mod IV). Inflation has the expected signs and statistically significant except when we control for the time effects (Banking, sovereign and covid crisis). The significance disappears from the GMM specification (Mod IV) once we account for persistence of the dependent variable and potential endogeneity.

Turning our attention to the case where CDS is the dependent variable in table 3, the results appears a bit different. The fiscal sustainability parameter is significant and positive only in the the static fixed effects case. Hence, there is some evidence that CDS premia respond to fiscal sustainability under static specifications, but this relationship is not robust in dynamic models once we account for persistence of the CDS. The same can be said about laggeddebt which is only significant in the static model with puzzling negative sign. GDP growth however, is statistically significant with the expected sign for all the model specifications. Output gap on the other hand is only significant in the static model. Controlling for time effects does not significantly impact the estimates. Overall, we have seen that the the baseline results are not driven by institutional differences between Euro and non-Euro Area economies. Restricting the sample to Euro Area countries does not materially change the sovereign spread results much, as fiscal sustainability remains insignificant across linear specifications. However, for CDS spreads, the results suggests that the pricing of fiscal sustainability in sovereign risk markets is less robust once persistence and endogeneity are accounted for.

Next, we test the hypothesis that sovereign risk market respond to fiscal sustainability decision in an asymmetric way. Hence we resort to a non-linear regime switching model where the non-linearity is condition on a transition variable (debt to GDP ratio). Existing studies on sovereign risk consistently identify public debt as one of the most important determinants of sovereign borrowing costs. For instance Ciżkowicz et al (2025) found that that deficit and debt remained the two most significant drivers of yields even after sovereign debt crisis is taken into account. Beyond its empirical relevance, debt may also play a role in how how markets interpret fiscal conditions. At relatively low debt levels, investors may attach limited importance to fiscal adjustment because debt dynamics remain manageable. However, as debt rises and concerns regarding fiscal solvency intensify, markets may become increasingly attentive to governments' fiscal responses and their commitment to debt stabilization. This gives rise to the following research question: does the relationship between fiscal sustainability and sovereign risk depend on the prevailing debt regime? To answer the above question, we refer to (8) and (9) and allow the effect of fiscal sustainability on sovereign risk to vary endogenously across debt levels using a PSTR framework.

Before we begin with the estimation, we conduct a pre-specification test in order to motivate our chosen non-linear PSTR from an econometric point of view known as linearity test or homogeneity test. This test entails a PSTR model specification and testing the null hypothesis of setting the parameters in the model to zero as against an alternative of non-zero parameter. A PSTR model with one transition (two regimes) and two transitions (3 regimes) are specified as the unrestricted models. Table 10 and 11 provides evidence of a rejection of the linearity hypothesis for both models with sovereign spread and CDS as dependent variable according to the p-values of the Lagrangian Multiplier (LM) test based on the F-distribution and Chi-square distribution. Furthermore tables 12 and 13 depicts the so-called sequence of homogeneity test. They both provide evidence of plausibility of a two regime model (1 transition) for the data since the p-values have the strongest rejection of the null hypothesis [1]. We therefore proceed with a two regime model where laggeddebt is the transition variable and a threshold value separating the two regimes of low and high debt.

[1]See Gonzalez et al. (2017) and Teräsvirta (1994), Owusu et al. (2025) for a detailed discussion of the homogeneity and sequence of homogeneity test.

Table 3: Euro Area subsample - Panel Static and Dynamic models

	Sovereign Spread				***CDS***			
	FE		*GMM*		*FE*		*GMM*	
Variables	Mod I	Mod II	Mod III	Mod IV	Mod V	Mod VI	Mod VII	Mod VIII
Lagged dependent variable			0.8273***	0.7936***			0.9294***	0.8372***
			(0.0864)	(0.1456)			(0.0669)	(0.1153)
Fiscal parameter (β)	-0.0706	-0.0753	0.0118	0.0118	0.1650**	0.1445**	-0.0934	-0.2860
	(0.0639)	(0.0575)	(0.0155)	(0.0188)	(0.0745)	(0.0642)	(0.3701)	(0.6434)
Lagged debt	0.0188***	0.0233***	0.0020	0.0020	-0.0417***	-0.0352***	0.0018	0.0075
	(0.0064)	(0.0049)	(0.0016)	(0.0033)	(0.0063)	(0.0054)	(0.0053)	(0.0093)
GDP Growth cap.	-0.1639***	-0.1517***	-0.1238***	-0.0887**	0.0552**	0.0407*	-0.0374*	-0.0474*
	(0.0257)	(0.0236)	(0.0295)	(0.0429)	(0.0238)	(0.0207)	(0.0221)	(0.0259)
Inflation	0.0786*	0.0720**	0.0786***	0.0444	0.0551**	0.0516**	0.0584*	0.0264
	(0.0400)	(0.0360)	(0.0283)	80.0643)	(0.0275)	(0.0238)	(0.0303)	(0.0686)
Current Account (% GDP).	0.0027	-0.0004	-0.0096	-0.0003	0.0172	0.0152	-0.0143	-0.0038
	(0.0261)	(0.0235)	(0.0120)	(0.0182)	(0.0225)	(0.0197)	(0.0337)	(0.0550)
Output gap	-0.1013***	-0.0936	0.0434	0.0413	-0.1816***	-0.1823***	0.0082	0.0044
	(0.0281)	(0.0267)	(0.0276)	(0.0628)	(0.0267)	(0.0232)	(0.0334)	(0.0481)
Banking Crisis		0.2217		1.3530		0.7316		3.9954
		(0.3868)		(2.3098)		(0.4570)		(3.7156)
Sovereign Debt Crisis		7.7022***		5.6826		0.6448		0.1277
		(1.0578)		(4.7619)		(0.5789)		(1.3346)
Covid Crisis		-1.4225***		-0.3994		-1.1586***		-0.0844
		(0.0267)		(0.4718)		(0.1482)		(0.4189)
Autocorrelation test II			-1.34(0.18)	-1.16(0.24)			1.47(0.13)	0.15(0.87)
Sargan Test			10.48(0.9)	8.31(0.9)			14.91(0.9)	10.05(0.9)
Observ	374	374	374	374	208	208	208	208
Indiv effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effects	No	Yes	No	Yes	No	Yes	No	Yes
Two-step weighting matrix			Yes	Yes			Yes	Yes

Standard errors are indicated in parentheses. *, ** and *** indicates statistical significance at 10%, 5% and 1% respectively. Standard errors are based on HAC scheme (static model) and a two-step weighting matrix (GMM). Hence they are robust against autocorrelation and heteroskedasticity. The GMM instruments used are as follows: Mod I to Mod III - 5 lags of the sovereign spread, 1 lag of inflation, 1 lag of the fiscal parameter, 1 lag of investment, 1 lag of current account, 1 lag of debt and 1 lag of GDP growth rate.

Table 4 presents estimate from the PSTR model, with debt to GDP ratio as transition variable and two regimes namely, a low debt and a high debt regime. It can be noted that in the case of sovereign spread, the threshold separating the two regime is given by roughly 61% which corresponds closely to the Maastricht Treaty reference debt threshold. In the case of CDS, the debt threshold is slightly higher at about 73% that separates the two regimes. The estimation from the sovereign spread market indicates that markets reward stronger fiscal responsiveness/sustainability since we observe a negative significant sustainability coefficients in the low debt regime. In the high debt regime (above 61%), even a stronger fiscal sustainability increases spread. A feasible explanation could be that markets may no longer perceive fiscal adjustment alone as a guarantee to restore sustainability especially as debt exceeds the Maastricht treaty reference. The laggeddebt variable have similar effects; namely in a low debt regime, market rewards lower debt and punishes high debt with a higher spread. This is consistent with Bi (2012), who found that default risk premia start to emerge when the debt level reaches a point where sovereign default becomes possible, hence high risk premium is associated with higher debt at a certain debt threshold. Regarding the effects of the control variables, GDP growth reduces sovereign risk in both regimes whilst increases in inflation is associated with increases in spread in both regimes. A positive current account balance is associated with a reduction in sovereign spread in both regimes implying that a stronger external balance is perceived as less risky for borrowers, hence investors demand lower interest rate premiums. Similarly a positive output gap is associated with lower spreads in both regimes.

The situation differs for some variables in the case of CDS market. An increase in fiscal adjustments/sustainability in a low debt environment is associated with increases in CDS premia and the opposite effect is observed in the high debt regime. At a high debt level, fiscal adjustment implies a reduction in default risk. Although the result may initially appear surprising, we observe that the estimated debt threshold for CDS markets is substantially higher (about 72%) than that observed for sovereign spreads. Since CDS contracts primarily insure against sovereign default risk, additional fiscal adjustment may not be perceived as necessary for debt stabilization and could instead signal emerging fiscal vulnerabilities especially at moderate debt levels. However, at a very high debt level, investors are likely to perceive a higher fiscal adjustment especially at elevated debt levels may more favorably due to institutional mechanisms such as fiscal adjustment programs for EU countries (for instance the European commission's excessive deficit procedure). Afonso (2024) obtained a similar results namely; as debt exceeds 90% of GDP, fiscal sustainability is associated with a negative response from the CDS market. One possible explanation is that investors may regard fiscal adjustment as more informative when debt reaches elevated levels, since the credibility of future debt stabilization becomes increasingly relevant for sovereign risk assessment. Nevertheless, an important distinction exists between the two approaches. While Afonso et al. (2024) identify debt regimes through an ex ante (manual) partition of the sample and estimate separate weighted least squares regressions for each regime, this study allows regime transitions to emerge endogenously through a Panel Smooth Transition Regression framework. Consequently, the estimated relationship between fiscal sustainability and sovereign risk evolves continuously across debt conditions rather than relying on predefined debt classifications. It can also be observed that increases in inflation is associated with positive spread in the low regime and a negative effect in the high debt regime and hence does not depend on the level of debt.

Overall, the relationship between fiscal sustainability and sovereign risk appears to be nonlinear and regime dependent. While stronger fiscal responsiveness lowers sovereign spreads under low debt conditions, the effect reverses once debt exceeds approximately 60 percent of GDP. In contrast, CDS markets appear to price fiscal sustainability differently, with stronger fiscal adjustment becoming more relevant for reducing default risk at elevated debt levels.

To complete our analysis, we estimate a Eurozone sample and present the results in table 5. The debt and CDS thresholds separating the two regimes in the Euro area are slightly higher than the full sample (about 67% and 81% respectively) Once again a statistically negative effect of the fiscal adjustment parameter can observed in the low debt regime and a positive effect in the high debt regime. Within the euro area, fiscal sustainability is associated with lower sovereign spreads at relatively low debt levels implying that markets reward governments that react to debt accumulation, whereas beyond the estimated threshold additional fiscal adjustment is associated with higher sovereign risk premia. Hence, markets appear to perceive fiscal responses at elevated debt levels as signals of fiscal distress rather than indicators of improved fiscal credibility. This is consistent with De Grauwe and Ji (2013) who argued that investors became increasingly

Table 4: Regime Switching (PSTR)

	Sovereign Spread		*CDS*	
Variables	Mod I	Mod III	Mod V	Mod VII
Low Debt Regime				
Fiscal parameter (β)	-0.2039***	-0.1324***	0.0047***	0.0762***
	(0.0893)	(0.0400)	(0.0019)	(0.0309)
Lagged debt	-0.0336***	-0.0253***	-0.0015***	-0.0517***
	(0.0002)	(0.0000)	(0.0003)	(0.0162)
Current Account (% GDP).	-0.1231***	-0.0796***	-0.0066***	0.0265
	(0.0561)	(0.0106)	(0.0007)	(0.0537)
GDP Growth cap.	0.0206	-0.0513***	-0.0293***	0.1355**
	(0.0681)	(0.0175)	(0.0040)	(0.0581)
Inflation	0.0924	0.2049***	0.0411***	0.3260**
	(0.0649)	(0.0284)	(0.0030)	(0.1479)
Output gap	-0.1078***	-0.1302***	0.0485***	-0.1254***
	(0.0349)	(0.0201)	(0.0033)	(0.0203)
Banking Crisis		0.7513		9.442***
		(0.2350)		(3.3010)
Sovereign Crisis		-21.3500***		3.0470***
		(1.3800)		(0.5383)
Covid Crisis		1.8620*		1.315
		(0.9924)		(1.3000)
High debt Regime				
Fiscal parameter (β)	0.2675***	0.1719***	0.0005	-0.0381**
	(0.0252)	(0.057)	(0.0079)	(0.01900)
Lagged debt	0.0137	0.0155*	-0.0021***	0.0210***
	(0.0087)	(0.0078)	(0.0000)	(0.0080)
Current Account (% GDP).	0.0212	-0.0450***	-0.0538***	-0.2468***
	(0.0748)	(0.0160)	(0.0104)	(0.0166)
GDP Growth cap.	-0.1838***	-0.0717***	-0.0283***	-0.0859***
	(0.0858)	(0.0205)	(0.0032)	(0.0305)
Inflation	0.2285***	0.0760**	0.05147**	-0.3105***
	(0.0781)	(0.0370)	(0.0068)	(0.0624)
Output gap	-0.2811***	-0.2655***	0.0279	-0.1678***
	(0.0387)	(0.0274)	(0.0058)	(0.0139)
Banking Crisis		-0.4414		-3.665***
		(0.2909)		(1.5710)
Sovereign Debt Crisis		18.1700***		0.9554***
		(4.4380)		(0.3186)
Covid Crisis		-3.5290***		-3.7840***
		(1.347)		(0.6296)
Observ	462	462	260	260
Threshold	60.8	60.9	72.9	72.9
Indiv effects	Yes	Yes	Yes	Yes
Time effects	No	Yes	No	Yes

Estimation of parameters from (8) and (9) using PSTR. Standard errors are indicated in parentheses. *, ** and *** indicates statistical significance at 10%, 5% and 1% respectively. Standard errors are based on HAC scheme, hence, they are robust to serial correlation and heteroskedasticity.

worried about elevated debt levels in the Eurozone, and therefore reacted by raising the spreads.

For CDS markets, an increase in fiscal adjustment is not significant in low debt regime indicating lack of evidence of responsiveness of markets. However at higher debt level (above 81%) market perceive further fiscal adjustment as not credible or even fiscal distress and therefore associated with higher perceived default risk. This is evident by a positive and statically significant fiscal sustainability parameter in the high debt regime. This interpretation is broadly consistent with Ghosh et al. (2013a), who argue that within a monetary union, limited monetary flexibility and reduced fiscal space may increase investors' concerns regarding sovereign solvency. Under such conditions, fiscal adjustment may be interpreted as a response to deteriorating fiscal conditions, potentially leading to higher sovereign bond yields and CDS premia as markets reassess sovereign risk. We can also observe that in the Euro area sample, the reaction of sovereign spread and CDS market to fiscal adjustment is very similar especially at elevated debt levels. The time effects are also mainly statically significant. For instance, the sovereign debt crisis period had a positive effect on spreads especially in the high debt regime and mixed for low debt regime. This is once again consistent with Ghosh et al (2013a) who found that CDS and bond yields rose more sharply for eurozone members during the european debt crisis than would be predicted based on their available fiscal space. Likewise the banking crisis which is also associated with mixed effects on the CDS in both regimes. The covid crisis appears to be associated with a reduction in both sovereign spread and CDS in the high debt regime. This could possible due to the expansive monetary interventions and coordinated fiscal responses during the covid period which reduced immediate financing pressures for highly indebted Euro Area sovereigns despite deteriorating fiscal balances.

In summary, the Euro Area results confirm the presence of nonlinearities in sovereign risk pricing. These findings suggest that investors interpret fiscal adjustment differently across debt regimes and that institutional features of the Euro Area may delay the point at which fiscal sustainability becomes incorporated into sovereign risk pricing. This is feasible because the debt threshold at which markets begin changing their assessment of fiscal sustainability appears higher than the full sample.

Table 5: Estimation results PSTR - Euro Area

	Sovereign Spread		*CDS*	
Variables	Mod I	Mod II	Mod III	Mod IV
Regime I - Low debt ratio				
Fiscal Parameter (β)	-0.2569*	-0.1478*	-0.1729	-0.1101
	(0.1509)	(0.0743)	(0.1753)	(0.0853)
Lagged debt	-0.0598***	-0.0487***	-0.0689	-0.0637
	(0.0193)	(0.0160)	(0.0785)	(0.0544)
GDP Growth Cap	-0.0656***	0.0001***	0.0217	-0.0541
	(0.0592)	(0.0012)	(0.0396)	(0.0312)
Inflation	0.0526***	0.1805***	0.1178	0.1606
	(0.0121)	(0.0472)	(0.1529	(0.1699)
Current account (% GDP)	-0.2119	-0.1385***	-0.0486	0.0159
	(0.1038)	(0.0494)	(0.0381)	(0.09314)
Output gap	-0.1513***	-0.1700***	-0.1446***	-0.1468***
	(0.0069)	(0.00047)	(0.0414)	(0.0092)
Banking Crisis		0.9820***		5.7620
		(0.1588)		(3.5150)
Sovereign Debt Crisis		-17.6300**		2.4770***
		(7.9270)		(0.4405)
Covid Crisis		2.363*		0.0942
		(1.2830)		(1.4110)
Regime II - High debt ratio				
Fiscal Parameter (β)	0.3680***	0.2326***	0.1379***	0.0621***
	(0.0476)	(0.0123)	(0.0024)	(0.0105)
Lagged debt	0.0210***	0.0212***	-0.0007	0.0030***
	(0.0075)	(0.0025)	(0.0036)	(0.0004)
GDP Growth Cap	-0.2533***	-0.1165***	-0.0644***	-0.0298***
	(0.0192)	(0.0069)	(0.0003)	(0.0129)
Inflation	0.1423***	-0.0459***	-0.1837***	-0.2526***
	(0.0016)	(0.0116)	(0.0186)	(0.0264)
Current account (% GDP)	0.1697***	0.0610***	-0.1381***	-0.2272***
	(0.0415)	(0.0171)	(0.0208)	(0.0315)
Output gap	-0.1917***	-0.1845***	-0.0472***	-0.1124***
	(0.0029)	(0.0040)	(0.0089)	(0.0070)
Banking Crisis		-0.6193***		-1.2170***
		(0.0951)		(0.0051)
Sovereign Debt Crisis		17.4900***		0.0184***
		(1.5250)		(0.3801)
Covid Crisis		-4.0060***		-2.7930***
		(0.2047)		(0.0959)
Threshold value(c)	66.67	66.67	81.29	81.29
Number of observations	374	374	208	208

Estimation of parameters from (8) and (9) using PSTR. *, ** and *** are significance of 1% , 5% and 10%. Standard errors are based on HAC scheme, hence, they are robust to serial correlation and heteroskedasticity.

5 Conclusion

This paper empirically examines the impact of the sustainability of the fiscal stance on sovereign risk. Using a two-step procedure, we constructed a time-varying measure of the sustainability of fiscal policy based Bohn-type fiscal reaction function, which measures the responsiveness of the primary balance to changes in public debt. Unlike conventional debt indicators that capture the level of indebtedness, the fiscal sustainability parameter reflects fiscal policy behavior and the extent to which governments adjust fiscal positions to stabilize public debt dynamics.

Using a panel of 21 European Union countries and considering both sovereign bond spreads and CDS premia as alternative measures of sovereign risk, the analysis evaluates whether financial markets respond to fiscal sustainability and whether this relationship varies across debt regimes. The linear panel estimates based on fixed effects and dynamic GMM models provided limited evidence that sovereign markets systematically price fiscal sustainability. Across both sovereign spread and CDS specifications, the fiscal sustainability parameter remains largely insignificant, while macroeconomic determinants including debt, GDP growth and inflation continue to explain sovereign risk. Restricting the analysis to Euro Area countries yields broadly similar conclusions, suggesting that the baseline findings are not driven by institutional differences between Euro and non-Euro Area economies. To account for possible non-linearities, the paper extends the analysis using a Panel Smooth Transition Regression (PSTR) framework in which the debt-to-GDP ratio serves as the transition variable. The nonlinear estimates reveal strong evidence of regime dependence. For sovereign spreads, stronger fiscal responsiveness reduces sovereign risk under low debt conditions but becomes associated with higher spreads once debt exceeds the estimated threshold. For CDS markets, the relationship also differs across debt regimes, suggesting that investors interpret fiscal adjustment differently depending on the prevailing debt environment and the level of sovereign indebtedness. The euro area subsample confirms the presence of nonlinearities while revealing higher debt thresholds relative to the full sample. The results for sovereign spread and CDS are mainly consistent especially at elevated debt levels. Overall, the results contribute to the sovereign risk literature by showing that debt levels alone may provide an incomplete representation of fiscal conditions as far as the sovereign debt market is concerned. Fiscal sustainability, measured through governments' fiscal responses to debt accumulation, contains additional information that becomes economically relevant once debt reaches sufficiently high levels. These findings highlight the importance of moving beyond linear approaches and considering state-dependent interactions between fiscal policy and sovereign risk.

References

Afonso, A., Alves, J. & Monteiro, S. (2024), "Sovereign risk dynamics in the EU: The time varying relevance of fiscal and external (im)balances", Journal of International Financial Markets, Institutions and Money, Vol. 94:102026

Afonso, A. & Jalles, J.T. (2019), "Fiscal Reaction Functions Across the World: In Quest of Statistical (In)significance", FinanzArchiv/Public Finance Analysis, vol. 75(3), pp. 207-228.

Afonso, A. (2005). "Fiscal sustainability: the unpleasant European case", FinanzArchive, 61, pp. 19–44

Aizenman, J. , Hutchinson, M.,& Jinjarak, Y., (2011). "What Is the Risk of European Sovereign Debt Defaults? Fiscal Space, CDS Spreads and Market Pricing of Risk", NBER Working Paper No. 17407.

Ardagna, S., Caselli, F., & Lane, T., (2007). "Fiscal discipline and the cost of public debt service: some estimates for OECD countries", B E J. Macroecon. 7 (1).

Bernoth, K., & Erdogan, B. (2012). "Sovereign bond yield spreads: A time-varying coefficient approach", Journal of International Money and Finance, 31(3), pp. 639–656.

Bi, H. (2012), "Sovereign default risk premia, fiscal limits, and fiscal policy", European Economic Review, vol. 56(3). pp. 389-410

Blundell, R. & Bond, S. (1998), 'Initial conditions and moment restrictions in dynamic panel data models", Journal of Econometrics, Vol. 87(1), pp. 115-143.

Bohn, H. (1998), "The behavior of U.S. public debt and deficits", Quarterly Journal of Economics, vol. 113(3) pp. 949-963.

Bohn, H. (1995), "The sustainability of budget deficits in a stochastic economy", Journal of Money, Credit and Banking, vol. 27(1), pp. 257-271.

Breitung,J & Eickmeier, S. (2011), "Testing for structural breaks in dynamic factor models", Journal of Econometrics, Vol. 163(1), pp. 71-84,

Ciżkowicz,P , Ledóchowski, M. & Rzońca, A. (2025), "Fiscal policy and government bond yields: New evidence from the EU",Economic Modelling, Vol. 147

De Grauwe, P. & Ji, Y., (2013). "Self-fulfilling crises in the eurozone: an empirical test", J. Int. Money Finance 34, pp. 15–36.

Federal Reserve Bank , (2025), "Interest Rates: Long-Term Government Bond Yields: 10-Year", FRED, `https://fred.stlouisfed.org/series/IRLTLT01ITM156N, Accessedon08.05.2025`

Feng,Q , Sun, X., Shen, Y. & Li, J. (2026), "Identifying time-varying and country-specific drivers of sovereign debt risk from credit rating reports", Information Processing & Management, Vol. 63(3), pp. 71-84,

Ghosh, A., Ostry, J., & Qureshi, M., (2013a). "Fiscal space and sovereign risk pricing in a currency unionv. *J. Int. Money Finance* 34, pp. 131–163.

Ghosh, A.R., Kim,J.I., Mendoza,E.G., Ostry, J.D., & Qureshi, M.S. (2013b). "Fiscal fatigue, fiscal space and debt sustainability in advanced economies." The Economic Journal, Vol. 123 (566): pp. F4-F30.

Global Macro Database , (2025), "A New International Macroeconomic Dataset", `http://www.nber.org/papers/w33714.Accessedon06.02.2025`

Gonzalez, A. T. Teräsvirta, D. Van Dijk & Yang, Y. (2017). "Panel smooth transition regression models," CREATES Research Paper 2017-36, pp. 1-47.

Greiner, A., & Fincke, B. (2016). "Public Debt, Sustainability and Economic Growth", Springer International Pu.

Hastie, T. & Tibshirani, R. (1993), "Varying-Coefficient Models", Journal of the Royal Statistical Society. Series B (Methodological), Vol. 55, No. 4 pp. 757-796

Hakkio, G,. & Rush, M. (1991). "Is the Budget Deficit Too Large?", Economic Inquiry, 29, pp. 429-445.

Owusu,B , Boekmeier, B. & Greiner, A. (2025), “Regime-based debt sustainability analysis: Evidence from euro area economies”, European Journal of Political Economy, Vol. 90,

Owusu B., Bökemeier, B. & Greiner, A. (2021). “Assessing Non-Linearities and And Heterogeneity in Debt Sustainability Analysis: A Panel Spline Approach,” Empirical Economics, 64(3), pp. 1315-1346.

Quintos, C. (1995), “Sustainability of the deficit process with structural shifts”, Applied Journal of Business Economic Statistics, 13, pp. 409–417.

Refinitiv (2025), `https://www.refinitiv.com/`, Accessed on 08.05.2025.

Stock, J.H. & Watson, M.W. (2009), “Forecasting in Dynamic Factor Models Subject to Structural Instability, In : Castle, J., Shephard,N.(Eds.),The Methodology and Practice of Econometrics, A Festschrift in Honour of Professor David F.Hendry” Oxford University Press,Oxford.

Teräsvirta, T. (1998). “Modelling economic relationships with smooth transition regressions,” in Handbook of applied economic statistics, ed. by A. Ullah, and D. E. A. Giles, pp. 507 - 552. New York: Marcel Dekker.

Teräsvirta, T. (1994). “Specification, estimation, and evaluation of smooth transition autoregressive models,” Journal of the American Statistical Association, 89 (425), pp. 208 - 218.

von Hagen, J., Schuknecht, L., & Wolswijk, G., (2011). “Government bond risk premiums in the EU revisited: the impact of the financial crisis”, Eur. J. Polit. Econ, 27 (1), pp. 36–43.

Wood, S. N. (2017). “Generalized additive models: An introduction with R” , (2nd ed.). Chapman and Hall/CRC.

World Bank (2025), “The Worldwide Governance Indicators (WGI)”, available at `https://info.worldbank.org/governance/wgi/`, last accessed: 05.02.2025

Yuan Ch, & Pongsiri TJ (2015), “Fiscal austerity, growth prospects, and sovereign CDS spreads: the Euro- zone and beyond”, Int Econ 141: pp.50–79

Appendix

Figure 3: Linear correlation Matrix

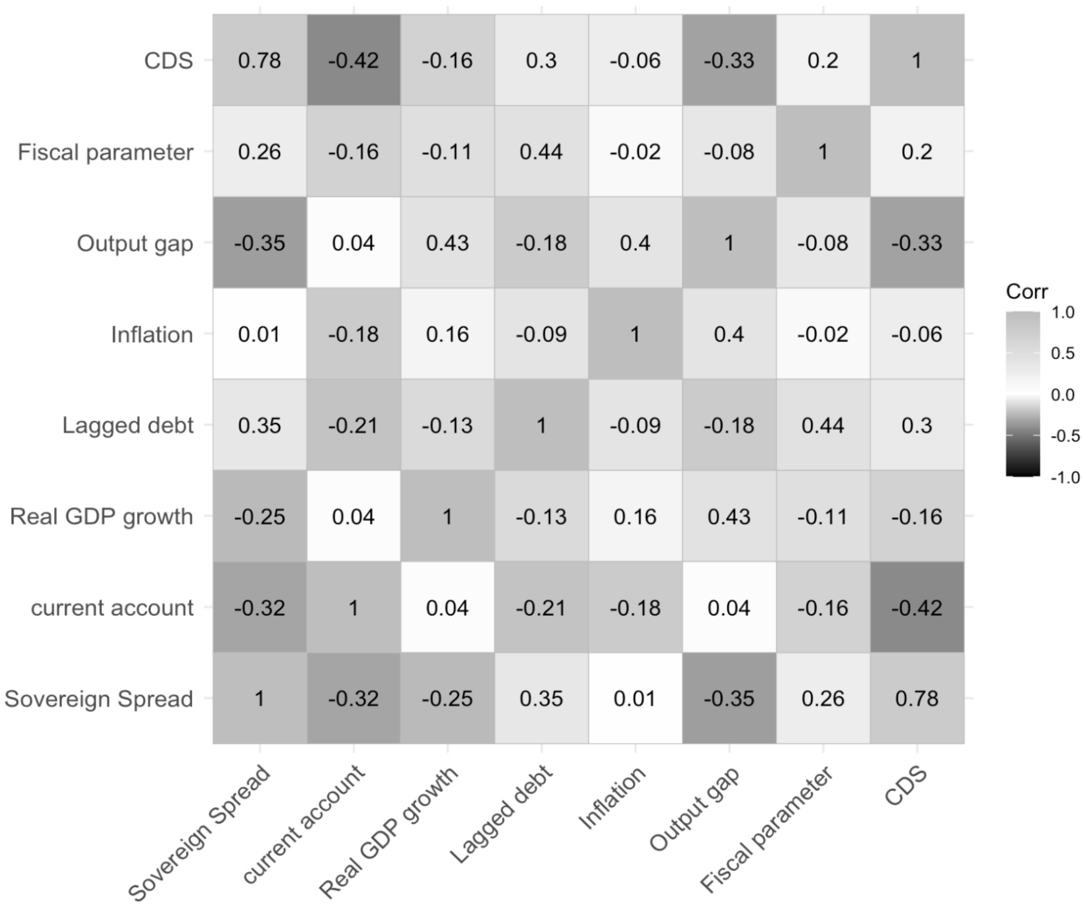


Table 6: Descriptive statistics of variables

Variable	Mean	SD	Min	P25	Median	P75	Max
Sovereign Spread	1.443	2.032	-1.200	0.300	0.600	2.175	21.000
Current account	-0.541	5.556	-23.892	-3.572	-0.041	3.089	12.165
Real GDP growth	1.920	3.889	-14.782	0.375	1.859	4.061	21.004
Lagged debt	65.424	36.532	7.435	40.321	58.872	84.682	213.152
Inflation	2.450	2.535	-1.689	0.934	2.039	3.184	17.276
Output gap	0.284	3.875	-13.100	-1.600	0.200	1.900	23.500
Fiscal parameter	-0.003	0.045	-0.116	-0.028	-0.006	0.026	0.099
CDS	4.049	1.495	1.623	3.039	4.009	4.783	9.609

Table 7: Panel Unit Root Test

	Im Pesaran and Shin		***Levin Lin and Chu***	
Variables	Test Stat	p-value	Test Stat	p-value
Sovereign Spread	-4.460***	0.000	-5.074***	0.000
Current account	-3.898***	0.000	-3.509***	0.000
Real GDP growth	-13.159***	0.000	-12.435***	0.000
Lagged debt	-0.194	0.423	-2.207**	0.014
Inflation	-1.539***	0.061	-1.867**	0.030
Output gap	-7.452***	0.000	-7.176***	0.000
Fiscal Parameter	-3.126***	0.001	0.625	0.734
CDS	-5.350***	0.000	-9.719***	0.000

Table 8: Data, Description and Source

Data	Description	Source
Sovereign Spread	Computed as the difference between respective 10-year yield for each country and the risk free rate	EC AMECO for all European yields, FRED for US yield
CDS	log of 5-year CDS spread (mid spread)	Refinitiv Eikon (now LSEG Workspace)
Debt	% of GDP	Global Macro database (GMD)
Current account	% of GDP	Global Macro database (GMD)
Real GDP growth	% change of real GDP per capita	Global Macro database (GMD)
Inflation	Annual changes in the CPI	Global Macro database (GMD)
Output gap	Deviation between actual and potential GDP (% potential GDP)	EC AMECO
Primary balance	Cyclical component of net lending (%)	EC AMECO
Banking crisis	Dummies 2007,2008,2011, 2014 and 2016 for applicable countries	Global Macro database (GMD)
European sovereign debt crisis	Dummies 2012-2013 for applicable countries	Global Macro database (GMD)
Covid-19 Pandemic	Dummies 2020-2021 for all countries	-
Fiscal parameter	Constructed from a Bohn-type fiscal reaction function	-

Table 9: Hausmann Test

	Sovereign Spread			***CDS***		
Model effects	F-stats.	P-value	Df	F-stats	P-value	Df
Individual only	23.429	0.001	6	54.99	0.0001	6
Individual and time	40.178	0.000	9	55.902	0.000	9

Table 10: Homogeneity (linearity) tests -Sovereign spread

	LM_{χ}		LM_F	
Transition	test stat.	p-value	test stat	p-value
2	101.5175	(0.0000)	5.2980	(0.0000)
1	77.9062	(0.0000)	8.3003	(0.0000)

Results of Langrangian multiplier test of homogeneity/linearity based on chi-square (LM_{χ}) and F distribution (LM_F). Null hypothesis of homogeneous coefficient is tested against an alternative hypothesis of heterogeneous coefficients (PSTR).

Table 11: Homogeneity (linearity) tests - CDS

	LM_{χ}		LM_F	
transition	test stat.	p-value	test stat	p-value
2	82.1528	(0.0000)	4.0725	(0.0000)
1	68.6586	(0.0000)	7.0713	(0.0000)

Results of Langrangian multiplier test of homogeneity/linearity based on chi-square (LM_{χ}) and F distribution (LM_F). Null hypothesis of homogeneous coefficient is tested against an alternative hypothesis of heterogeneous coefficients (PSTR).

Table 12: Sequence of homogeneity tests - Sovereign Spread

	LM_{χ}		LM_F	
Transition	test stat.	p-value	test stat	p-value
2 (H_{02}^*)	22.4468	(0.0008)	2.9691	(0.0019)
1 (H_{01}^*)	77.9062	(0.0000)	8.3003	(0.0000)

Results of LM sequence of homogeneity test based on chi-square and F distribution. m denotes the number of regime transitions. The hypothesis is based on the following parameters from (8) ; $H_0^* : cbeta_2^* = \beta_1^* = 0$, $H_{02}^* : \beta_2^* = 0$ and finally $H_{01}^* : \beta_1^* = 0|\beta_2^* = 0$

Table 13: Sequence of homogeneity tests - CDS

	LM_{χ}		LM_F	
Transition	test stat.	p-value	test stat	p-value
2 (H_{02}^*)	18.3347	(0.0315)	1.8178	(0.02179)
1 (H_{01}^*)	68.6586	(0.0000)	7.0713	(0.0000)

Results of LM sequence of homogeneity test based on chi-square and F distribution. m denotes the number of regime transitions. The hypothesis is based on the following parameters from 8 ; $H_0^* : cbeta_2^* = \beta_1^* = 0$, $H_{02}^* : \beta_2^* = 0$ and finally $H_{01}^* : \beta_1^* = 0|\beta_2^* = 0$