Sovereign bonds’ risk-based heterogeneity

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Abstract

Are sovereign risk premia subject to homogeneous effects from their drivers or, instead, are these effects specific to the risk class each sovereign bond belongs to? In the paper at hand, effects on sovereign bond risk premia stemming from macroeconomic, fiscal and volatility factors, are examined by considering the classification of sovereign riskiness. Panel data estimation techniques are used, for 30 countries, with data in quarterly frequency for the period 2001Q1 to 2019Q4. Sovereign spreads are found to be subject to heterogeneous effects associated with their credit ratings; spreads on sovereign bonds considered low-risk increase with higher growth rates and inflation, while high-risk spreads are more sensitive to idiosyncratic and global volatility. Primary fiscal surpluses indeed lower spreads, but cannot counterbalance the effects of volatility episodes. Our main findings are robust to various alternative setups, samples and control variables such as central banks’ asset purchases.

Keywords: sovereign risk; heterogeneity; credit ratings; volatility; fiscal deficit; debt; growth

JEL: F34; F45; G12; G15; H30

1. Introduction

The drivers of sovereign risk premia are very important regarding risk and public debt management; moreover, market signals serve as input to decisions taken both by investors and policymakers, concerning their portfolios and fiscal policies respectively. In this respect, the importance of understanding the drivers of sovereign risk premia is accentuated by the fact that, in the present elevated levels of debt worldwide, the low level of sovereign risk premia is a necessary condition for the viability of public debt (see, Blanchard 2019).

In the present paper, we take into account the lessons learned, so far, from the literature on sovereign bond spreads and highlight the importance of 'tailor-made' policy decision making. We show that drivers of risk premia are different for sovereigns considered risky, as compared to those considered riskless or of low risk. In this regard, policies aiming to rein in the cost of public debt should be designed by considering the category of risk each sovereign is deemed to belong to.

The literature on sovereign risk premia has grown vastly in the years following the Global Financial Crisis of 2007-2009 and the euro-area debt crisis of 2010-2012. Still, not in a uniform fashion.

On the one hand studies published in the early stages of the euro-area debt crisis saw the rise in sovereign risk premia as explained by the deterioration of the fiscal or external balances (see, e.g., Bernoth and Erdoghan 2012; Gruber and Kamin 2012; Mink and de Haan 2013; Beirne and Fratzscher 2013). Policy-wise, this strand of the literature saw markets as a disciplinary device for violators of fiscal rules (Manganelli and Wolswijk 2009). In this respect, lowering fiscal or external deficits (or higher surpluses) will lead to lower levels of sovereign risk premia.

On the other hand, De Grauwe and Ji (2013), showed that the point of view described above did not suffice to explain phenomena such as changes in investors' tolerance towards risk, systemic market turbulence and/or self-fulfilling expectations. In this regard, Favero (2013) argues that "[…] if markets can stay irrational longer than a country can stay solvent, then the role of yield spreads on national bonds as a fiscal discipline device is considerably weakened […]". So, at parallel another strand of the literature developed, arguing that the change in risk aversion or market sentiments, in the aftermath of the Global Financial Crisis, can better explain the spike in sovereign risk premia (see, e.g., Longstaff *et al.* 2011; Ang and Longstaff 2013; Gómez-Puig and Sosvilla-Rivero 2014; Chiarella *et al.* 2015; Delatte *et al*. 2017).

The significant reduction of euro-area sovereign risk premia, after Mario Draghi's pledge that the ECB will do "*whatever it takes*" to preserve the euro, has been taken, by and large, as a confirmation of the view that market confidence (or the lack of it) is a crucial determinant of spreads' movements (see, e.g., Saka *et al.* 2015). Therefore, the arguments developed by this point of view provide support for such policies as the central banks' asset purchases, outright monetary transactions, or even common bond issuances to provide a euro-area wide safe asset by bundling sovereign risks in tranches (e.g., Brunnermeier et al. 2016).

An interesting aspect of the effects of the determinants of sovereign risk premia, is their cross-section heterogeneity (e.g. D'Agostino and Ehrmann, 2013; Georgoutsos and Migiakis 2013). Hence, the importance of each driver of sovereign bond spread could depend on the characteristics of each sovereign, which produce the kind of heterogeneity reported in the literature. In this regard, we contribute to the literature on sovereign bonds *by allowing fundamental and volatility effects on spreads to depend on investors' views about the riskiness of each sovereign*. To the best of our knowledge, this is the first study explaining the heterogeneity across sovereign bonds, based on views about their riskiness.

We examine whether similar developments in macroeconomic and fiscal fundamentals as well as in global and country-specific volatility conditions affect spreads differently according to views about the riskiness of each sovereign. For this purpose, we associate sovereign bonds' reactions to fundamentals and other factors to credit ratings. We show that the same explanatory factors affect riskless sovereigns (e.g. AAA or AA), differently than low-risk sovereigns (e.g. A and BBB) or risky ones (BB and lower).

The present paper makes several additional contributions to the literature. Briefly, we find that spreads of sovereigns considered riskier are reduced by stronger economic conditions (i.e. positive real GDP growth and stronger consumer confidence), fiscal prudence (i.e. primary fiscal surpluses) and, less so, by benign public debt dynamics. Yields on bonds of sovereigns considered safer increase mainly with stronger economic conditions. Finally, we find idiosyncratic and global market volatilities affect spreads of riskier sovereigns in a particularly strong manner, whereas effects on safer sovereign bonds are substantially weaker.

The rest of the paper is organized as follows. Section 2 presents the model used herein in order to capture cross-section heterogeneities in sovereign spreads. Section 3 describes the data. Section 4 presents the estimation of the effects on sovereign spreads across rating categories. Finally, section 5 presents several robustness checks and section 6 concludes.

2. Modelling effects on sovereign spreads

2.1 Standard setups

Sovereign bond spreads are specified as mean-reverting stationary, albeit highly persistent, processes, that are affected both by country-specific and global risk factors (see, Favero 2013). The following relationship illustrates the standard setup used in panel data analyses, in its general form:

$$(R_{it} - R_{0t}) = \alpha_i + \rho \cdot (R_{it-1} - R_{0t-1}) + \gamma \cdot f_{it} + d \cdot v_t + e_{it}. \tag{1}$$

In equation (1) R_{0t} stands for the sovereign bond yield of the benchmark country, at each point in time (t), whereas R_{it} stands for the yield of the bond, with a similar term to maturity, of sovereign *i.* The difference between the two (i.e. $R_{\iota t} - R_{0t}$) is the sovereign bond yield spread. A fixed-effects constant (i.e., α_i) is added, as a standard way to capture country-specific, time-invariant, deterministic effects. Including an autoregressive term is dictated by high persistence. The variable v_t is introduced in order to capture volatility effects. Finally, we consider several macroeconomic and fiscal fundamentals, expressed by the vector f_{it}.

Variables related to fiscal balances serve to gauge the risks that stem from the dynamics of public debt and are included in standard setups. On the other hand, GDP growth, is another important parameter for debt's dynamics. According to Blanchard (2019) a more sustainable road towards the goal of lowering debt or sustaining its risk premia may be through strong real GDP growth rates, combined with the current low-interest environment. Still GDP growth has attracted much less attention, in the literature on the determinants of spreads.

A large part of the extant literature addresses the issue of effects stemming from macro and fiscal fundamental variables on spreads, within a forward-looking framework. So, by incorporating the notion of expectations of fundamentals, we get Equation (2):

$$(R_{it} - R_{0t}) = \alpha_i + \rho \cdot (R_{it-} \; - R_{0t-1}) + g \cdot E_t(f_{it+h}|\Omega_t) + \gamma \cdot m_{it} + d \cdot v_t + \epsilon_{it}. \qquad (2)$$

In the equation above, $E_t(\cdot\,|\Omega_t)$ is the expectations operator for a set of fiscal variables (denoted by *f*), given the set of information (*Ω*) at the time of expectations formation, while *m* denotes the rest of the macroeconomic fundamentals, that relate to economic activity and inflation. In this setup investors form expectations for the fiscal variables *h* periods ahead based on the information obtained at time *t*.

2.2 Risk-based heterogeneity

An important aspect that remains to be incorporated in the examinations of spreads, is that, at any given time, investors are not neutral towards the sovereign. They already have formed opinions about the riskiness of the sovereign, which may affect the way they discount economic developments. Thus, the sensitivity of the risk premia of a given sovereign on the expected fundamentals may be conditional on the investors' views about its riskiness.

The connection of views about sovereign riskiness, with the pricing of the sovereign's fundamentals would not be traceable under standard uniform, cross-section, formulations. So, we examine whether these views are associated to the kind of heterogeneity documented in the literature on sovereign spreads (e.g., Georgoutsos and Migiakis 2013; Delatte *et al*. 2017); i.e., different reactions of spreads, of different sovereigns, to similar developments in the underlying explanatory factors.

In order to examine this hypothesis, we associate the pricing of fundamentals with measures reflecting investors' views about the riskiness of the sovereign. Then, risk-based heterogeneity would be reflected by differences (a) either in the sensitivities (b) or the directions, of the effects exercised by similar developments in fundamentals, for sovereigns with different levels of risk. Econometrically, this can be examined by interacting the effects of macro and fiscal fundamentals with investors' views on the level of sovereign risk; see, Equation (3), below:

$$(R_{it} - R_{0t}) = \alpha_i + \rho_1 \cdot (R_{it-1} - R_{0t-1}) + g_1 \cdot E_t(f_{it+h}|\Omega_t) + \gamma_1 \cdot m_{it} + d_1 \cdot v_t +$$

$$+\rho_2 \cdot (R_{it-1} - R_{0t-1}) \cdot c_i + g_2 \cdot E_t(f_{it+h}|\Omega_t) \cdot c_i + \gamma_2 \cdot m_{it} \cdot c_i + d_2 \cdot v_t \cdot c_i + u_{it}. \quad (3)$$

In Equation (3), all determinants affect spreads according to existing views of investors about the riskiness of each sovereign, which are captured by c_i. To this end, the interaction of expected fiscal fundamentals ($E_t(f_{it+h}|\Omega_t)$), current (macroeconomic) fundamentals (m_{it}) and volatility variables ($\mathrm{v_t}$) with variables used to gauge investors' views on the riskiness of sovereigns, can be used to examine the effect of investors' views on sovereign risk for spreads. This way we allow the impact of fundamentals to be based on the level of sovereign risk.

How can views about sovereign riskiness result in heterogeneous reactions of sovereign spreads? A straightforward example draws from developments in fundamentals that are similar for two hypothetical sovereigns, but produce different movements of spreads because the two sovereigns belong to different classes of risk. A hypothetical adverse change in the fiscal balance of a sovereign that is viewed by investors as risky may lead to a persistent rise of the risk premia in its bonds, or even to stressed borrowing. At the same time, this development would not result in a similar rise in sovereign spreads for sovereign considered safe. Other examples can be drawn on hypothetical macroeconomic developments; a rise in real GDP growth rate may lower spreads of risky sovereigns, e.g. due to expectations about improved fiscal revenues, whereas it may not do so, if the credit risk component is minimal (e.g. in AAA-rated bonds).

On the other hand, behavioral channels may also produce heterogeneity. Specifically, it is very frequent for shifts in market sentiment to result in different directions of movements in highly rated bonds, vis-à-vis low-rated ones. For example, consider the anticipated lowering of spreads, due to lower fiscal deficits. During the euro-area debt crisis several Eurozone countries underwent fiscal consolidations, lowering their fiscal deficits and improving their debt sustainability profiles; at the same time, their spreads skyrocketed. This negative market reaction did not originate from country-specific fundamentals but from market sentiment; in particular, the fear of a break-apart of the Eurozone. The fact that it ended with the well-known pledge of the then president of the European Central Bank, is seen as a confirmation of the crisis' behavioral aspect (see, De Grauwe and Ji 2013; Saka *et al.* 2015).

2.3 Credit ratings as views of sovereign riskiness

Views about the level of risk of any given sovereign can be represented by taxonomies of risk across the spectrum, such as sovereign credit ratings. Ratings inform about the level of riskiness of each sovereign in comparison to others (Remolona *et al.*, 2007; Cavallo, *et al.* 2013). They are one of the main tools bond market investors use, for reflecting the level of riskiness of sovereign bonds (e.g. Livingston *et* al. 2010; Aizenmann *et al.* 2013; Malliaropulos and Migiakis 2018).

Credit ratings are assessments of the ability and willingness of a sovereign entity to respect its debt obligations in full. To analyze the risk that a sovereign may default on its obligations, credit rating agencies (CRA) assign alphanumeric values that inform investors about the riskiness of each sovereign, as perceived by the CRAs' boards of experts (i.e., the 'rating committees'), based on their assessment of fundamentals as well as on their views about the prospects of the economy (see, Fitch 2010; Moody's 2015; Standard and Poor's 2011).[1]

In the first stage, macro, fiscal, institutional, and political factors are assessed, while in the second, rating committees input their views about the prospects of the economy (see, among others, IMF 2010 and De Moor *et al.* 2018). The second stage entails judgment, in order to incorporate expectations about potential developments.[2] So, we estimate equation (4), below, in which we use ratings for the classification, at each point in time, of sovereigns to categories of riskiness:

$$(R_{it} - R_{0t}) = \alpha_i + \rho_1 \cdot (R_{it-1} - R_{0t-1}) + g_1 \cdot E_t(f_{it+h}|\Omega_t) + \gamma_1 \cdot m_{it} + d_1 \cdot v_t +$$

$$+\rho_2 \cdot (R_{it-} \; - R_{0t-1}) \cdot c_{it} + g_2 \cdot E_t(f_{it+h}|\Omega_{it}) \cdot c_{it} + \gamma_2 \cdot m_{it} \cdot c_{it} + d_2 \cdot v_t \cdot c_{it} + u_{it}. \qquad (4)$$

In Equation (4) ratings (i.e., variable c_{it}) represent views about the level of riskiness of each sovereign *i*, at each point in time *t*. This specification allows for the migration of sovereigns across groups of high or low risk. Thus, in equation (4) each sovereign does not belong to a predetermined class of risk for the entire sample, as would be the case if we had split the section of the sample into specific groups of countries (e.g., emerging vs. advanced economies or core vs. periphery euro-area countries). In the second line of equation (4), the terms interacting with ratings allow for capturing heterogeneous effects in sovereign spreads, classified according to the rating of the sovereign. To the extent spreads' cross-section heterogeneity is associated with sovereign riskiness, this part of the equation will be significant and will provide room for deviation of rating-specific effects from the across-the-board effects captured by the first part of the equation.

3. Estimation setup

3.1 Data

Yields of ten-year sovereign bonds are used in quarterly frequency, for 30 sovereigns from various regions of the world, while the period covered by our sample is from 2001Q1 to

[1] Note that we do not look for objective measures of sovereign risk (e.g. Singh *et al*. 2021), but rather for assessments of sovereign risk that form or at least reflect investors' views.

[S] See, among others, De Vries and De Haan (2016) and Lennkh and Moshammer (2018).

2019Q4.[3] We incorporate sovereigns from various regions and with wide dispersion in their underlying characteristics, exactly as this may result to heterogeneities.[4] We use ratings, from the three largest CRAs, in notch-level.[5] For fiscal fundamentals we use the debt-to-GDP ratio and primary balance-to-GDP (i.e. the difference between primary revenues and expenses as a ratio of GDP). For macroeconomic fundamentals we use the annualized growth of real GDP, inflation (measured by the year-on-year changes of CPI), consumer confidence and the bank credit-to-GDP ratio. For market conditions we employ volatility of domestic stock markets and the VIX. The source of all the series is Refinitiv.

In order to have gauges of expected fiscal figures that both span a wide range of countries and are of as high frequency as possible, we opt for extracting expectations econometrically.[6] For gauging debt, we rely on the identity of the debt-to-GDP growth process, as shown by the debt dynamics equation (5), below:

$$d_{it} = d_{it-1} + [(r_{it-1} - \pi_{it-}\ ) - g_{it-1}] \cdot d_{it-1} - s_{it} \tag{5}$$

In Equation (5), d_t is the ratio of debt to GDP at time t, r is interest paid on debt, π_{it} is the inflation rate, g_{it} is the real GDP growth rate and s_t is the primary balance-to-GDP which takes positive values in the case of a primary surplus or a negative one in the case of a deficit. Note that we use interest expenses as a ratio to GDP, i.e. the term denoted by $r_{it} \cdot d_{it}$ in equation (5); this variable reflects the actual cost of debt and not an implied one, as would be the case if we used the nominal bond yield times the debt-to-GDP ratio. We subtract from it inflation and the real GDP growth rate (again multiplied with the debt-to-GDP ratio), thus taking into account interest-growth dynamics.

Equation (5) illustrates the dynamics of public debt, in annual frequency, while it allows for the derivation of series of debt-to-GDP, in quarterly frequency; for this purpose, we simply use annualized quarterly data. The derived series of debt, serves as a measure of anticipated debt, as all parameters are *ex ante* known, i.e., before the level of debt is officially announced. Note also that a nonlinear relationship between public debt and sovereign spreads, has been

[3] Austria, Australia, Belgium, Brazil, Canada, Chile, Czech Rep., Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, S. Korea, Mexico, New Zealand, the Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Spain, Sweden, Turkey, United Kingdom and the United States.

[4] Spreads series are 10-year bond yields' differentials of the abovementioned countries vis-à-vis the yields of the US Treasury benchmark; the spread for the US is calculated vis-à-vis its 10-year swap rate. The US Treasury (UST) bonds have been used as an international benchmark in studies of bond yield differentials in, e.g. Du et al. (2018). For robustness we also used the German Bund as a benchmark for EA countries; the results do not change and they are available upon request.

[5] Ratings are transformed to numeric values based on the rule: AAA=1, AA+/Aa1=2, AA/Aa2=3, …, B+/B1=14, B/B2=15, B-/B3=16. We follow the 'second best' regulatory rule (see, among others, Avramov et al. 2007; Tewari et al. 2015).

[6] Forecasts for fiscal variables, from official sources or from surveys and polls are not available in quarterly frequency for all the countries of our sample.

documented in previous literature by including a squared term of the debt-to-GDP variable (e.g., Ghosh et al. 2013; Delatte et al. 2016); so, we also include a squared term of debt.

For the fiscal balance, we use the government budget constraint (see, e.g., Ghosh *et al.* 2013). In this context we obtain anticipated values of the primary balance (i.e. s_t) based on the fiscal reaction function, including effects from real GDP growth rates, as shown below in (6):

$$s_{it} = c + \alpha \cdot g_{it-4} + \beta \cdot (d_{it} - d_{it-4}) + \varepsilon_t \quad (6)$$

In equation (6) the primary fiscal balance surplus, as a ratio to GDP, is derived as an in-sample forecast, based on the fiscal reaction term (β), capturing the sensitivity of primary balance to the anticipated change in debt-to-GDP, an economic activity term (α), capturing the sensitivity of primary balance to the real growth rate (g_t) and a constant term c, capturing all other macro variables pertaining to the determination of the budget balance. Equation (6) provide an econometric specification of the expected fiscal balance; it implies that the fiscal reaction to changes of the debt-to-GDP ratio and to growth affect the budget balance four quarters ahead.

Next, we take note of the covariation of real GDP growth, consumer confidence and bank credit.[7] We isolate the common information in each variable by orthogonalizing them vis-à-vis their common factors. So, we take the residuals from the regression of real GDP growth to consumer confidence and bank credit-to-GDP. This way, our 'orthogonalized' real GDP growth variable, mostly accounts for the factors that drive real economic activity, other than such forward-looking factors as confidence and bank credit. In a similar vein, we take the residuals from the regression of consumer confidence variable to bank credit-to-GDP, in order to isolate effects on consumer sentiment driven by credit.

Regarding the expected sign of the coefficients, we expect that variables related to economic activity and bank credit may be either related with a negative or a positive sign to spreads. For example, on the one hand, higher real GDP growth rates in developed (and inherently less risky) economies may lead investors to form expectations for higher future short-term rates, thus resulting in a positive sign in the coefficient. On the other hand, for riskier sovereigns, i.e., ones with weak economic activity or structural weaknesses, a stronger real GDP growth rate may lead to receding investor concerns over the sovereign's ability to produce revenues and serve its debt, thus resulting in negative signs in the coefficient.

Finally, the volatility variables are used to reflect effects from both global and idiosyncratic, country-specific, volatility on sovereign bond spreads. On the one hand, the VIX index on the implied volatility of the S&P500 share price index options is used to capture global volatility conditions, following previous literature (among others, Ang and Longstaff 2013; Arghyrou and Kontonikas 2012). On the other hand, the global risk factor, captured by the VIX index,

[7] Financial variables are increasingly shown to contain significant information about economic activity (e.g. Ma and Zhang, 2016).

does not count for episodes of increased volatility, related to idiosyncratic risks or country-specific risk aversion.

For this purpose, we have also constructed country-specific volatility variables, from daily stock market returns, by using a standard GARCH-M (1,1) technique in a time series setting (i.e., country-specific regressions) for each one of the 30 countries of our sample.[8] VIX is inserted in the variance equation as an exogenous factor. Then, by means of Maximum Likelihood estimation techniques we take the common factor out of the derived country-specific volatilities in order to isolate the idiosyncratic component of stock market volatility. This way, we examine both idiosyncratic and global volatility.[9]

3.2 Estimation

About the choice of estimation techniques, we take into account the properties of the data. On the one hand, it seems necessary to include a first-order autoregressive term in the specification, in order to capture the high persistence of the dependent variable.[10] On the other hand, we take into account concerns about the correct estimators, based on the time and section dimensions of the panel data set (see, Hsiao and Zhang, 2015).[11]

In light of these concerns, and given the fact that system GMM estimators can be biased if certain auxiliary assumptions are violated (Arellano 2016), we have opted for the Feasible Generalized Least Squares estimator, with fixed effects and cross-section weights, which is robust in the presence of panel heteroscedasticity and contemporaneous cross-section correlations (Bai et al. 2021).[12] So, the simple Feasible Generalized Least Squares (FGLS) fixed-effects estimator with cross-section weights, to account for cross-sectional heteroscedasticity, provides efficient estimates. Heterogeneous variances and cross-section weights are standard estimation techniques for capturing cross-section heterogeneity and, thus, included in our estimation setup. But, if the dependent variable’s reactions to its explanatory variables follow a deterministic cross-section classification these techniques may not suffice. In this case it is necessary to introduce a variable that classifies deterministic effects across the section dimension of the sample.

4. Empirical analysis

4.1 Results

In this section, we present the estimations of equation (4) that includes rating-specific effects on spreads. We introduce separately each variable interacted with ratings, in the setups that

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[8] The results of these estimations are, also, available upon request.

[9] The cross-section average correlation coefficient of VIX and the country-specific volatilities we estimate is around 10%.

[10] In a technical Appendix we compare results of static specifications to those under the dynamic setups. The Appendix is available upon request.

[11] In our case, we have N=30 cross section and T=76 time series observations.

[12] Note that we have also estimated a dynamic system GMM setup, with Arellano-Bond instruments; the results are not substantially different and are available upon request to interested readers.

include across-the-board effects from all determinants, under columns 1 to 8. Then we combine them in one model, shown under column 9. Table (1) reports the results:

[Insert Table 1, around here]

The results in Table 1 indicate that by including rating-specific effects we capture significant cross-section variations of the determinants; this specification is, thus, advantageous compared to a standard uniform estimation, in which only the across-the-board effects are included. The coefficients of the determinants of spreads do not change significantly, in the complete setup (model 9), vis-à-vis the specifications in which determinants are included one at a time and in interaction with ratings.

Moreover, finding that the determinants' interactions with ratings, are significant, on top of including fixed effects and cross-section weights, indicates that the information of the rating-specific effects, i.e., the effects that stem from the variables when they interact with ratings, is not adequately captured in standard specifications for heterogeneous panel data models. This is clearly demonstrated in the case of fiscal variables (i.e., primary balance and the debt-to-GDP ratio); when introducing these variables interacted with ratings, the across-the-board significance (shown in specifications 1, 2 and 9, of Table A2) is eliminated. This observation seems to confirm that the effects of the determinants, when they interact with ratings, absorb the deterministic component that would, otherwise, be captured by the cross-section average coefficients of these variables.

Fiscal variables (i.e. primary balance and the debt-to-GDP variables, in level and squared terms), are found to exercise significant effects when they are interacting with ratings. This indicates that fiscal effects are heterogeneous, across different rating categories. Indeed, if we calculate the contribution of each variable on spreads, we find that there is a substantial dispersion of their effects across rating categories.

[Insert Figure 1, around here]

In particular, a high deficit, which for illustrative purposes we assume to be equal to 5% of GDP, *ceteris paribus*, adds 16-20 basis points on spreads of triple-BBB rated bonds (i.e. BBB+, BBB or BBB-) and up to 28 to 32 basis points for single-B bonds (i.e. B+, B or B-). On the other hand, it only adds 2 to 8 basis points for riskless bonds (i.e. bonds in the high rating categories of AAA and AA). Reversely, if we consider positive fiscal balances, highly rated sovereign bond spreads are affected only to a minimal degree compared to low-rated ones.

A similar picture is drawn when we focus on the effects exercised on spreads by the level of debt. In fact, the heterogeneity of the effects exercised on sovereign spreads is very clear when we focus on the level of public debt.

[Insert Figure 2, around here]

As shown in Figure 2, above, the dispersion of the effects stemming from public debt is quite large and demonstrates clearly non-linear characteristics. For example, *ceteris paribus*, even for high levels of public debt, e.g., 175% of GDP, the additional premium paid by sovereigns rated in the range of AAA to AA- is from minimal to small; from 17 to 68 basis points. The average level of debt, at the end of our sample, for this category is around 75% of GDP; as a result, according to our findings, this adds only minimal to their spreads over the US Treasury bond yield (i.e. 1 to 2 basis points). At the end of our sample, the average debt-to-GDP ratio for the sovereigns rated in the range of AA+ to BBB- is around 85%; this corresponds to a premium paid in their sovereign bonds that belongs in the range of 10 to 17 basis points, according to their rating, i.e. multiple times higher than that of the highly-rated bonds, even though the difference in the average debt level is not wide. Finally, spreads on sovereign bonds rated in the range of BB+ to B-, would encompass a premium of 20 to 30 basis points, for similar levels of debt, *ceteris paribus*.

However, at present, governments have accumulated higher debts due to the fiscal support to address the economic effects of the Covid-19 pandemic. Indeed, if we consider higher debt ratios, the dispersion of the effects is even more pronounced. For example, a debt level equal to 125% of GDP would add 7 basis points to the spread of a triple-A sovereign, 78 basis points to a BBB one and 120 basis points to a B-. Or a debt level equal to 175% of GDP would affect a AAA sovereign by adding only 17 basis points to its spread, 155 basis points to a BBB and 275 basis points to a B-.

Next we focus on the effects of volatility on spreads; our findings are in line with those of previous studies that have shown that it is one of the main drivers of spreads. Still, our analysis differs in two main aspects from that of previous literature: we disentangle global and idiosyncratic volatility effects and show that their effects are larger the worse the ratings of the sovereigns are.

[Insert Figure 3, around here]

Figure 3 above illustrates the effects on spreads, exercised by various levels of VIX, across sovereign rating categories. We find that under low volatility conditions (e.g., when VIX and idiosyncratic volatilities belong to the 10% lower historical values), volatility effects are minimal. For example, a value of VIX at the bottom 10% of its historical distribution, only adds 6 to 10 bps to spreads of sovereign bonds rated AAA to AA- (i.e. high-rated sovereigns); if idiosyncratic volatilities are at levels equivalent to their distribution's bottom 10% they add 2 to 5 basis points more (see, Figure 4 below). The same values affect sovereigns rated in the range of A+ to BBB- (i.e. bonds in the low-IG categories) by adding 11 to 17 bps (for VIX) and 6 to 15 bps for idiosyncratic volatilities, whereas for sovereigns rated below the IG threshold lower (i.e. in the range of BB+ to B-) volatilities add 19 to 25 bps (VIX) and 17 to 24 bps (idiosyncratic volatilities), on average.

[Insert Figure 4, around here]

However, in case of a volatility spike, the picture changes; effects stemming from market volatilities are larger and affect much more the lower or low-rated sovereigns, than the high-rated ones. Hence, a spike of VIX at values in the upper 10% of its historical distribution (i.e., VIX>30), translates to an effect on spreads in the range of 19 to 30 bps, for bonds rated in the range of AAA to AA-, 33 bps to 52 bps for sovereigns in the range of A+ to BBB- and 56 bps to 74 bps for sovereigns rated BB+ to B-. Additionally, if such a market turbulence is more pronounced for some countries, thus resulting in a similar spike of idiosyncratic volatility in the top 10% of its historical distribution, this would add 6 to 24 bps more, for high-rated sovereigns, 30 to 60 bps for sovereigns in the low-IG categories and, finally, the same development would have an effect on low-rated sovereigns in the range of 66 to 96 bps.

Are these anticipated rating-specific effects of volatility on spreads confirmed out-of-sample? The financial turbulence caused by the Covid-19 pandemic offers a volatility-episode example; in a period of roughly three weeks, VIX escalated from around 15.6 (value, just before the volatility escalation, as of 21 February 2020) to 82.7 (VIX's peak value, during the Covid-19 episode, as of 16 March 2020). Based on our findings, the observed rise of VIX produces an increase of 39 bps, on average, in the spreads of highly-rated sovereigns (from as high as AAA to as low as AA-), 70 bps for low-IG sovereigns (i.e. in the range of A+ to BBB-) and 155 bps for low-rated ones (BB+ to B-). Actually, during the three-week period of the Covid volatility episode, spreads of sovereign bonds, of countries belonging to our sample, rated in the range of AAA to AA-, rose (on average) by 30 bps, trough-to-peak. Spreads of A+ to BBB- bonds rose by an average of 40 bps, while BB+ to B- bond spreads rose, on average by 177 bps. So, the Covid volatility shock seems (a) to confirm the finding of heterogeneous reactions of spreads, associated to sovereign riskiness and (b) to prove the accuracy of our model's anticipated effects.

[Insert Figure 5, around here]

As shown in Figure 5, above, economic activity, also seems to affect spreads in a rating-specific manner. The effects stemming from real GDP growth are non-linear, across ratings, due to the opposite sign of the coefficient of the variable interacting with ratings in comparison to the corresponding sign of the across-the-board coefficient. Thus, whereas positive rates of growth of real GDP lead to rises in spreads of highly-rated sovereigns, they have the opposite effect for lower-rated ones, driving spreads of bonds rated lower than A, to lower levels even for very modest growth rates.

[Insert Figure 6, around here]

Similar are the results for consumer confidence, as shown in Figure 6, above; consumer confidence's effects on spreads follow a similar non-linear pattern. Note that consumer confidence is usually seen as a 'soft indicator' of near-term economic activity, e.g., in DSGE models (see, e.g., Bańbura and Rünstler 2011). So, in high-rated economies a hypothetical stronger economic activity or stronger confidence about the prospects of the economy are likely to give rise to expectations about higher future short-term rates. On the other hand, for sovereign bonds with a low- or lower-rating, a higher growth rate or a stronger economic confidence provides higher comfort about factors important for the repayment of debt, such as the stream of public revenues or a lower debt-to-GDP ratio. Interestingly, while economic confidence's effects on high-rated sovereign bonds are similar, but subdued in magnitude, to those exercised by the GDP growth rate, they are much broader for low-rated sovereigns. Thus, a measurement of consumer confidence indicating expectations about stronger economic activity, in low-IG and non-IG bonds, effectively lowers their risk premia.

Inflation is found to exercise rating-specific effects, as well; a given rise in inflation is found to add more to spreads of lower sovereign ratings. For example, a one standard deviation rise in the inflation rate, i.e. of about 1.5%, is found to add 12 bps to AAA bonds, around 70 bps to A-rated bonds and 108 bps to BB-rated ones.

4.2 Policy implications

So what do these results say about economic policies that aim to lower sovereign bond spreads? We illustrate policy implications of the results presented above, by two fiscal policy scenarios, illustrated in figures 7 and 8, below. Restrictive (upper panels) and expansionary (lower panels) fiscal policies are considered, under different scenarios of economic growth and confidence in Figure 7, while in Figure 8 we also add volatility scenarios.

[Insert Figure 7, around here]

In Figure 7, in the upper (/lower) panel, the results of a restrictive (/expansionary) fiscal policy, defined as one that results in a primary surplus (/deficit) of 2.5% of GDP, are classified (a) according to the rating of the sovereign and (b) according to states of growth and confidence. We specify three scenarios for growth and confidence: the 'strong growth' scenario assumes a 3% rate of growth of real GDP and strong (positive) consumer confidence, the 'weak growth' scenario assumes a 1% rate of growth of real GDP and positive but low confidence and, finally, the 'recession' scenario assumes a growth rate of real GDP at -1% and negative consumer confidence indicator.

This exercise shows that, according to our findings, policies resulting in primary surpluses may indeed lower spreads, but only if the rate of growth of real GDP is positive; the reduction effect is even more pronounced the lower the rating of the sovereign is. However, this is not the case for negative real GDP growth rates; even under mild recessionary conditions, using restrictive fiscal policies in order to lower risk premia in bonds rated lower than single-A, proves a self-defeating strategy in line to Di Pietro *et al.* (2021).

[Insert Figure 8, around here]

Now, if we also take into account fiscal policies in the light of volatility effects on top of those exercised by growth, the outcome is even more interesting and realistic (see Figure 8). Again, in the two panels of Figure 8 the same paths for fiscal policy are examined (i.e., the upper panel presents results based on primary surplus of 2.5% of GDP and the lower panel presents effects of a primary deficit of 2.5% of GDP). The rest of the conditions are similar to those of Figure 7, with the addition of volatility effects: we examine states of low- (bottom 25% of the historical distributions of VIX and idiosyncratic volatilities), average- (median of the historical distributions of VIX and idiosyncratic volatilities) and high-volatility (upper 25% of the historical distributions of VIX and idiosyncratic volatilities).

In a nutshell, we find that the effects of fiscal policy as a tool for lowering spreads depend on broader market and economic conditions. Importantly, volatility may have more than offsetting effects, reversing the benefits from prudent economic policies.

5. Robustness checks

5.1 Fiscal variables: alternative specifications

As a first battery of robustness checks of the above results, we focus on the effects exercised by fiscal variables. We examine alternative specifications of fiscal variables. The first includes fiscal variables in contemporaneous values; this specification implies that there is no forward-looking aspect in bond spreads about fiscal fundamentals. The second specification entails the introduction of fiscal variables with a time lead; this specification examines a rule of expecting fiscal fundamentals with perfect predictive accuracy.

Table 2, below, reports the results of the abovementioned specifications with alternative measures for fiscal variables. Column (1) presents results under the first alternative of static expectations and column (2) reports results for the 'perfect foresight' expectations.

[Insert Table 2, around here]

Results reported in Table 2, by and large, confirm the robustness of the baseline specification for all the non-fiscal variables. Second, if anything, the alternative specifications of fiscal variables are found to contain information that is weaker than the ones of our baseline model, about spreads. In more detail, these specifications confirm the significance of the ratings-specific contribution of fiscal variables on sovereign spreads.

5.2 Cross-section alternative specifications: groups of countries

Another battery of robustness checks is formulated with the aim to examine other forms of cross-section nonlinearities. The working hypothesis in this section is that by separating the sample, into standard groups used in the previous literature, the cross-section heterogeneity, captured by the variables interacted with ratings, will be eliminated. This would constitute evidence that other forms of nonlinearities, and not necessarily the views on sovereign riskiness, would drive the heterogeneity revealed in the previous sections. We examine two forms of sample separation across the section of countries included in our sample: on the one hand, euro-area (EA) vis-à-vis non euro-area (non-EA) countries and on the other, Investment Grade (IG; i.e. rated BBB- or better) vis-à-vis non-Investment Grade (non-IG; i.e. rated BB+ and lower) ones.

The first sample separation, i.e., to EA and non-EA, intends to investigate whether our results are driven by euro-area countries. The second sample separation, to IG and non-IG sovereigns, is justified because of regulatory treatments of the IG threshold, for example due to the risk weighting schemes in banks' capital adequacy or collateral frameworks.[13] Thus, in Table 3 below, the results of the investigation of the above-described grouping formations are examined. Results under columns (1) and (2) report findings for the comparison of EA and non-EA countries, respectively, while results under columns (3) and (4) report findings for countries whose ratings are within or lower than the IG threshold.

[Insert Table 3, around here]

Table 3 reports results very similar to the ones reported for the baseline specification, for both pairs of sample sets. Almost all effects exercised on spreads, follow the same structure in terms of significance and signs, while the rating-specific effects indicate that the finding of different magnitudes or even direction of effects, according to the riskiness of the sovereign, remains. Although some differences exist, between EA and non-EA or IG and non-IG countries, these are limited and do not affect our results substantially.

For instance, the across-the-board effects from primary balance are significant only for EA countries, while non-EA ones are affected by this variable on a rating-specific manner. So, the countries' sample-separation, in this case, provides a deeper understanding of our results; EA sovereign bonds are affected in a more homogeneous way, by fiscal balance, than do non-EA

[13] For capital adequacy, see, IMF (2010) and Drago and Gallo (2016). For collateral, see, among others, Pelizzon *et al*. (2016) and Bindseil *et al*. (2017).

sovereigns. On the other hand, a refinement is provided concerning the public debt ratio variable, as it is found to be significant only for EA-sovereigns and, similarly to our baseline model of Table 1, in their rating-specific version only.

However, this finding is better understood if we look at the results of non-IG sovereigns; there, as expected both the debt-to-GDP and the primary fiscal balance are significant, both across sections and in a rating-specific fashion. The importance of modeling the ratings-dependent contribution of spread determinants is evident in each one of the separate groups of countries we examined. This implies, first, that our results are not driven by a particular group of countries or rating categories and second, that a large part of the heterogeneity of effects exercised on spreads is indeed treated when one considers the sovereign riskiness classification.

5.3 Alternative sample periods

Another set of robustness checks aims to examine whether our results stand for a particular period of our sample, but not the rest of the periods. Indeed, this check is warranted because the Global Financial Crisis resulted in the re-pricing of risks, produced by changes in the structure of the underlying relationships of sovereign spreads and their determinants. So, why not affecting our results as well? In Table 4, below, we report results for three sub-periods (before, during and after the GFC[14]), for the entire sample of countries (see, results under columns 1 to 3) and the euro area (columns 4 to 6).

[Insert Table 4, around here]

The finding of heterogeneity associated with the risk classification of the sovereigns remains, across periods and groups of countries. Furthermore, ratings-dependent public debt ratios and across-sections primary balances are significant for the entire group of countries, only during the post-GFC period (column 3). At the same time, fiscal variables turn to be significant for the EA countries over the post-GFC period, having both across-the-board and rating-specific effects (column 6). Several results are worth exploring further: for example, while the bank credit variables had not been found, till this check, to be significant, as a determinant of sovereign spreads, we now find that it plays a significant role for euro-area sovereign spreads, post-GFC. A thorough examination of this finding, we leave for future research.

5.4 Controlling for asset purchase programs

Finally, we include variables that capture central banks' asset purchase programs; we use data for domestic government bond purchases by central banks.[15] The first variable, reflects the

[14] Note that the GFC period is taken to have lasted from the third quarter of 2007, until the first quarter of 2009; i.e. from the freeze of money markets (August 2007) until the launch of the QE1 program by the Fed (March 2009).

[15] Country-specific purchases by the ECB under PSPP (with the exception of Greece that did not participate), United States, United Kingdom, Japan, Australia, Canada.

volume of these purchases as a ratio of the country's GDP, at each point in time, the second is the ratio of the volume of the central bank's government bond purchases to total public outstanding bonds (in book value). The third variable captures quarterly flows of CB's purchases to flows of new government bond issuances by each country and the fourth is the difference between the ratio to GDP of government bond holdings of the domestic central bank to that of the Fed for US Treasury bonds. Table 5, below, presents the results.

[Insert Table 5, around here]

First, our findings show that central banks' government bond purchases, as measured by the first and the second specifications, have exercised significant reduction effects on sovereign spreads. For each 1% of GDP of government bond purchases the reduction is 75 basis points.[16] These results are in line with similar findings in the literature on the effects of central banks' asset purchases on sovereign bond yields and spreads (e.g. Neely 2015; De Santis and Holm-Hadula 2019). Of course, other studies, focusing exactly on the effects of unconventional monetary policies on sovereign bonds and other economic or financial variables, offer a more exhaustive examination of this issue, than ours. In the context of the robustness check, we are interested to reflect on the changes the introduction of these variables may entail to our setup.

Interestingly, while we do find that purchases of government bonds by central banks have exercised significant reduction effects on sovereign spreads, the main thesis of our paper remains robust. In particular, sovereign bond spreads, by and large, are specified in a heterogeneous fashion, associated with the rating of each sovereign. Consequently, there is strong evidence that economic fundamentals and volatility variables affect spreads differently according to the riskiness of the underlying sovereign bonds.

6. Conclusion

We have examined whether the relationship between sovereign spreads and their determinants depends on views about sovereign riskiness. For this purpose, we use ratings for classifying sovereign states to risk groups at each point in time, thus capturing heterogeneous effects on sovereign bonds across sections due to the level of sovereign riskiness. In this way, the setup we use reflects different pricing processes for such variables as global and idiosyncratic volatility, expected fiscal primary balance, expected debt, real growth, inflation, consumer confidence, and bank credit-to-GDP, according to widely used, by investors, measures of the riskiness of each sovereign.

[16] That explains, for example, a 160 basis points reduction of Italian spreads, 180 basis points for Spanish ones and 150 basis points reduction in British spreads.

The findings of the paper at hand underline the importance, both for the econometrician and the policymaker, to appropriately address the high degree of heterogeneity, in panel data analyses of sovereign bond spreads. In the opposite case, correct readings of spreads' movements belonging to a given class of riskiness, may not be equally successfully employed in cases of sovereigns belonging to different classes of risk.

Indeed, we find that there is a wide asymmetry in the effects exercised by sovereign spreads' determinants, which is related to the riskiness of the sovereign. In this regard, the focus of investors seems to be different for different levels of sovereign risk. For sovereigns considered safer, spreads are found to be more sensitive to the prospects of higher growth rates and inflation, while spreads of low-rated states are found to reflect investor concerns, captured by idiosyncratic volatility and global volatility, while stronger economic activity and primary surpluses lower spreads.

Also, we show that while fiscal consolidation has been a necessary condition for addressing the rise in the cost of borrowing by sovereigns in those cases that fiscal imbalances produced investor uncertainty, it has not been a sufficient one as well. So, fiscal consolidation should not be the only focus of policies aiming at easing financing conditions faced by sovereigns with problematic market access; global and domestic uncertainty-inducing factors could more than offset the lowering effects of re-balancing economic policies on risk premia.

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Table 1 – Effects on spreads associated with sovereign riskiness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	-0.194* (0.082)	-0.211* (0.085)	-0.168* (0.082)	-0.199* (0.082)	-0.107 (0.079)	-0.126** (0.085)	-0.113** (0.079)	-0.202* (0.083)	-0.007 (0.080)
Spreads(-1)	0.884** (0.016)	0.876** (0.015)	0.884** (0.016)	0.872** (0.016)	0.881** (0.015)	0.868** (0.016)	0.883** (0.015)	0.879** (0.016)	0.915** (0.015)
$E_t(Primary_{t+4})$	-0.011 (0.006)	-0.028** (0.005)	-0.029** (0.005)	-0.029** (0.005)	-0.023** (0.005)	-0.031** (0.005)	-0.031** (0.005)	-0.030* (0.005)	-0.008 (0.007)
$E_t(Debt_{t+4})$	-0.003* (0.001)	-9.65×10^{-4} (0.002)	-0.003* (0.001)	-0.003 (0.002)	-0.002 (0.001)	-0.004* (0.001)	-0.004* (0.001)	-0.003* (0.001)	0.001 (0.002)
$E_t(Debt^2_{t+4})$	1.34×10^{-5}* (5.55×10^{-6})	-3.50×10^{-7} (1.07×10^{-5})	1.41×10^{-5}* (6.10×10^{-6})	1.34×10^{-5}* (6.08×10^{-6})	1.35×10^{-5}* (5.85×10^{-6})	1.56×10^{-5}** (5.47×10^{-6})	1.66×10^{-5}** (5.43×10^{-6})	1.24×10^{-5}* (5.34×10^{-6})	-8.70×10^{-6} (1.11×10^{-5})
Inflation	0.044** (0.008)	0.045** (0.008)	0.024* (0.010)	0.043** (0.008)	0.033** (0.007)	0.047** (0.008)	0.042** (0.007)	0.045** (0.008)	0.009 (0.009)
Real GDP growth	0.022** (0.005)	0.025** (0.005)	0.025** (0.005)	0.035** (0.007)	0.022** (0.005)	0.022** (0.005)	0.022** (0.005)	0.023** (0.005)	0.027** (0.006)
Consumer Confidence	0.002 (0.001)	0.002* (0.001)	0.002* (0.001)	0.002* (0.001)	0.007** (0.001)	0.002 (0.001)	0.002 (0.001)	0.002* (0.001)	0.005** (0.001)
Bank credit-to-gdp	3.63×10^{-4} (4.90×10^{-4})	1.03×10^{-4} (4.82×10^{-4})	1.81×10^{-4} (4.83×10^{-4})	2.44×10^{-4} (4.90×10^{-4})	1.26×10^{-4} (4.62×10^{-4})	-1.60×10^{-4} (0.001)	-7.58×10^{-5} (4.72×10^{-4})	1.30×10^{-4} (4.91×10^{-4})	2.08×10^{-4} (5.65×10^{-4})
VIX	0.008** (0.002)	0.008** (0.002)	0.007** (0.002)	0.007** (0.002)	0.007** (0.001)	0.008** (0.002)	0.003 (0.002)	0.009** (0.002)	0.005** (0.002)
Idiosyncratic Volatility	0.003 (0.004)	0.003 (0.0004)	0.004 (0.005)	0.004 (0.004)	0.005 (0.004)	0.003 (0.003)	0.005 (0.004)	-0.011* (0.005)	-0.003 (0.006)
Spreads(-1) *ratings	-0.002 (0.002)	-3.05×10^{-4} (0.002)	-0.002 (0.002)	5.49×10^{-4} (0.002)	-0.005* (0.002)	2.14×10^{-4} (0.002)	-0.001 (0.002)	-7.19×10^{-4} (0.002)	-0.011** (0.002)
$E_t(Primary_{t+4})$ *ratings	-0.004** (0.001)								-0.004** (0.001)
$E_t(Debt_{t+4})$* ratings		-2.49×10^{-4} (2.62×10^{-4})							-0.001* (4.28×10^{-4})
$E_t(Debt^2_{t+4})$* ratings		2.66×10^{-5} (1.93×10^{-5})							6.11×10^{-6}** (2.35×10^{-6})
Inflation *ratings			0.005** (0.002)						0.008** (0.002)
Real GDP growth *ratings				-0.003* (0.001)					-0.004* (0.002)
Consumer Confidence *ratings					-0.003** (4.89×10^{-4})				-0.003** (5.39×10^{-4})
Bank credit-to-gdp *ratings						1.12×10^{-4}* (5.20×10^{-5})			1.08×10^{-4} (1.23×10^{-4})
VIX*ratings							0.002** (4.16×10^{-4})		1.23×10^{-3}* (6.29×10^{-4})
Idiosyncratic Volatility *ratings								0.004* (0.001)	0.003* (0.001)
Cross section FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Period	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4
Obs.	1914	1914	1914	1914	1914	1914	1914	1914	1914
Adj. R-squared	0.947	0.959	0.944	0.944	0.943	0.946	0.944	0.945	0.942
Durbin-h	2.108	2.097	2.053	2.075	2.015	2.043	2.046	2.044	2.062

Note: Panel FGLS estimates with fixed effects and robust standard errors (cross-section weights), for the period 2001Q1-2019Q4, for 30 sovereigns. Numbers in parentheses refer to standard errors. Asterisks * and ** denote 5% and 1% significance.

Table 2 – Alternative specifications of fiscal variables		
	(1)	**(2)**
Intercept	-0.176 (0.089)	-0.206* (0.087)
Spreads(-1)	0.902** (0.016)	0.908** (0.015)
$Primary_t$	-0.003 (0.005)	
$Debt_t$	0.002 (0.002)	
$Debt_t^2$	-3.18×10^{-6} (1.15×10^{-5})	
$Primary_{t+4}$		-0.007 (0.004)
$Debt_{t+4}$		0.002 (0.002)
$Debt_{t+4}^2$		-9.71×10^{-6} (1.10×10^{-5})
Inflation	0.011 (0.009)	0.008 (0.009)
Real GDP growth	0.036** (0.007)	0.037** (0.009)
Consumer Confidence	0.006** (0.001)	0.007** (0.001)
Bank credit-to-gdp	5.55×10^{-4} (5.61×10^{-4})	3.57×10^{-4} (5.61×10^{-4})
VIX	0.006** (0.002)	0.006** (0.002)
Idiosyncratic Volatility	-0.004 (0.006)	-0.005 (0.006)
Spreads(-1)*ratings	-0.007** (0.002)	-0.007** (0.002)
$Primary_t$*ratings	-0.002* (0.001)	
$Debt_t$*ratings	-7.79×10^{-4} (4.39×10^{-4})	
$Debt_t^2$ *ratings	4.17×10^{-6} (2.46×10^{-6})	
$Primary_{t+4}$*ratings		1.70×10^{-4} (6.86×10^{-4})
$Debt_{t+4}$*ratings		-8.23×10^{-4} (4.27×10^{-4})
$Debt_{t+4}^2$ *ratings		4.59×10^{-6}* (2.31×10^{-6})
Inflation*ratings	0.004* (0.002)	0.004* (0.002)
Real GDP growth*ratings	-0.005** (0.001)	-0.006* (0.002)
Consumer Confidence*ratings	-0.003** (0.001)	-0.003** (4.93×10^{-4})
Bank credit-to-gdp*ratings	-1.63×10^{-5} (1.23×10^{-4})	-3.12×10^{-6} (1.20×10^{-4})
VIX*ratings	0.001 (0.001)	0.001* (6.04×10^{-4})
Idiosyncratic Volatility*ratings	0.002 (0.002)	0.002 (0.001)
Cross section FE	Yes	Yes
Period	2001Q1 to 2019Q4	2001Q1 to 2019Q4
Obs.	1988	2040
Adj. R-squared	0.942	0.941
Durbin-h	2.067	2.179

Note: Panel FGLS estimates with fixed effects and robust standard errors (cross-section weights), for the period 2001Q1-2019Q4, for 30 sovereigns. Numbers in parentheses refer to standard errors. Asterisks * and ** denote 5% and 1% significance.

Table 3 – Cross-section checks: EA vs. non-EA, IG vs. non-IG				
	EA	**Non-EA**	**IG**	**Non-IG**
Intercept	-0.507* (0.233)	0.079 (0.112)	-0.421** (0.087)	-8.160** (2.721)
Spreads(-1)	0.871** (0.027)	0.916** (0.023)	0.902** (0.017)	0.221 (0.272)
$E(Primary_{t+4}\|t)$	-0.029* (0.013)	0.007 (0.010)	0.002 (0.007)	0.493** (0.167)
$E(Debt_{t+4}\|t)$	0.009 (0.006)	-0.003 (0.002)	$4.34\text{x}10^{-4}$ (0.002)	0.785** (0.167)
$E(Debt_{t+4}\|t)^2$	$-7.32\text{x}10^{-5}$ $(3.99\text{x}10^{-5})$	$2.24\text{x}10^{-5}$ $(1.34\text{x}10^{-5})$	$7.43\text{x}10^{-6}$ $(1.11\text{x}10^{-5})$	-0.003** $(7.33\text{x}10^{-4})$
Inflation	0.009 (0.019)	-0.011 (0.010)	0.026** (0.009)	0.047 (0.411)
Real GDP growth	0.049** (0.011)	0.022** (0.008)	0.047** (0.007)	-0.364 (0.404)
Consumer Confidence	$-4.84\text{x}10^{-4}$ (0.004)	0.005** (0.001)	0.009** (0.001)	-0.046 (0.142)
Bank credit-to-gdp	$-7.30\text{x}10^{-4}$ $(9.29\text{x}10^{-4})$	$6.92\text{x}10^{-4}$ $(8.73\text{x}10^{-4})$	0.001* $(5.04\text{x}10^{-4})$	-0.068 (0.064)
VIX	0.006* (0.003)	$6.04\text{x}10^{-4}$ (0.002)	0.011** (0.002)	-0.385* (0.186)
Idiosyncratic Volatility	-0.017* (0.008)	-0.001 (0.011)	0.005 (0.005)	-0.507 (0.267)
Spreads(-1)*ratings	-0.014** (0.003)	-0.019** (0.004)	-0.013** (0.004)	0.018 (0.018)
$E(Primary_{t+4}\|t)$*ratings	-0.001 (0.003)	-0.005** (0.001)	-0.004** (0.001)	-0.040** (0.012)
$E(Debt_{t+4}\|t)$*ratings	-0.004** $(7.08\text{x}10^{-4})$	$-2.50\text{x}10^{-4}$ $(6.30\text{x}10^{-4})$	$-4.30\text{x}10^{-4}$ $(4.04\text{x}10^{-4})$	-0.061** (0.013)
$E(Debt_{t+4}\|t)^2$*ratings	$2.42\text{x}10^{-5}$** $(3.92\text{x}10^{-6})$	$-1.22\text{x}10^{-6}$ $(3.05\text{x}10^{-6})$	$1.71\text{x}10^{-6}$ $(2.46\text{x}10^{-6})$	$2.49\text{x}10^{-4}$** $(5.23\text{x}10^{-5})$
Inflation*ratings	0.029** (0.006)	0.011** (0.002)	0.002 (0.003)	0.016 (0.032)
Real GDP growth*ratings	-0.007* (0.003)	-0.005* (0.002)	-0.005** (0.001)	0.035 (0.034)
Consumer Confidence*ratings	-0.002* (0.001)	-0.002** $(6.49\text{x}10^{-4})$	-0.003** $(5.93\text{x}10^{-4})$	0.003 (0.011)
Bank credit-to-gdp*ratings	$3.49\text{x}10^{-4}$ $(1.97\text{x}10^{-4})$	$-1.03\text{x}10^{-4}$ $(2.95\text{x}10^{-4})$	$-4.06\text{x}10^{-5}$ $(1.27\text{x}10^{-4})$	0.014* (0.005)
VIX*ratings	0.004** (0.001)	0.002** $(7.16\text{x}10^{-4})$	0.001* $(5.41\text{x}10^{-4})$	0.040* (0.016)
Idiosyncratic Volatility*ratings	0.009** (0.002)	-0.003 (0.002)	$3.98\text{x}10^{-4}$ (0.001)	0.039* (0.019)
Cross section FE	Yes	Yes	Yes	Yes
Period	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4	2001Q1 to 2019Q4
Obs.	828	1086	1764	150
Adj. R-squared	0.918	0.956	0.949	0.928
Durbin-h	2.287	1.927	2.024	1.895

Note: Panel FGLS estimates with fixed effects and robust standard errors (cross-section weights), for the period 2001Q1 to 2019Q4, for 30 sovereigns. Numbers in parentheses refer to standard errors. Asterisks * and ** denote 5% and 1% significance.

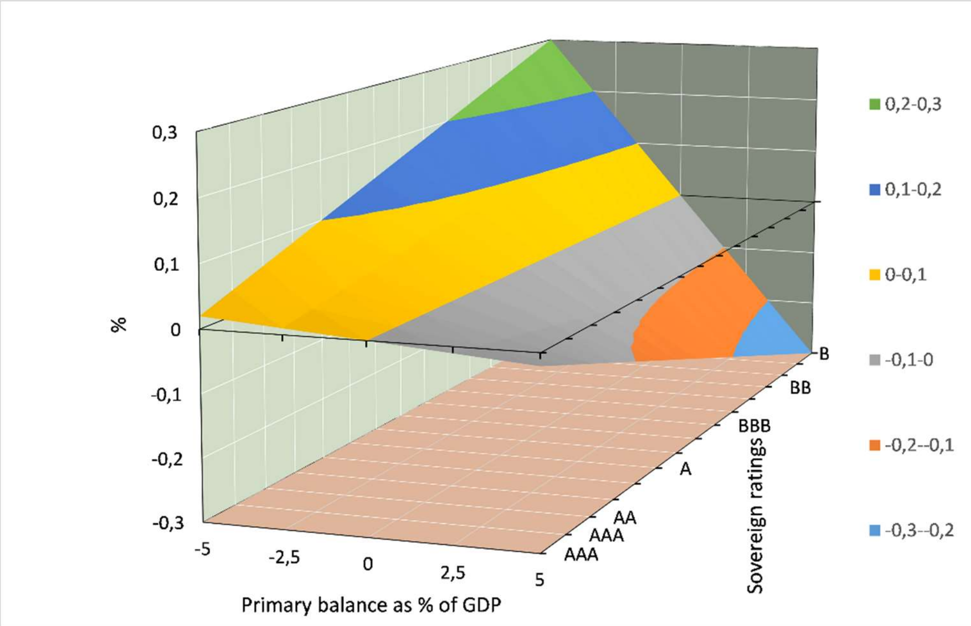
Table 4 – Period checks: all countries and euro-area group						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Intercept	-0.868** (0.292)	-1.529** (0.500)	-0.122 (0.216)	-0.608 (0.518)	0.451 (1.585)	-2.215** (0.741)
Spreads(-1)	0.877** (0.033)	0.383** (0.086)	0.867** (0.023)	0.734** (0.067)	-0.389 (0.284)	0.813** (0.042)
$E_t(Primary_{t+4})$	0.059** (0.014)	-0.090** (0.020)	-0.026* (0.011)	-0.026 (0.025)	0.001 (0.031)	-0.043* (0.021)
$E_t(Debt_{t+4})$	0.004 (0.007)	0.003 (0.011)	0.006 (0.005)	-0.003 (0.012)	-0.018 (0.030)	0.070** (0.017)
$E_t(Debt^2_{t+4})$	$1.56x10^{-5}$ ($4.53x10^{-5}$)	$3.39x10^{-5}$ ($5.40x10^{-6}$)	$-2.24x10^{-5}$ ($3.28x10^{-5}$)	$8.44x10^{-6}$ ($8.19x10^{-5}$)	$4.28x10^{-4}$ ($1.75x10^{-4}$)	$-4.67x10^{-4}$** ($1.12x10^{-4}$)
Inflation	-0.018 (0.017)	0.056* (0.026)	0.001 (0.015)	-0.013 (0.026)	0.040 (0.051)	0.075* (0.036)
Real GDP growth	0.018 (0.012)	0.042* (0.018)	0.036** (0.009)	0.029 (0.016)	0.018 (0.022)	0.052** (0.019)
Consumer Confidence	0.002 (0.003)	0.013** (0.004)	0.008** (0.002)	0.004 (0.006)	-0.050** (0.015)	-0.007 (0.007)
Bank credit-to-gdp	0.004** (0.001)	0.003 (0.004)	-0.001 (0.001)	0.002 (0.002)	0.008 (0.010)	-0.004* (0.002)
VIX	0.008** (0.002)	0.003 (0.004)	0.013** (0.004)	0.027** (0.004)	-0.006 (0.006)	0.013 (0.009)
Idiosyncratic Volatility	0.017* (0.008)	-0.005 (0.007)	-0.033* (0.013)	-0.011 (0.008)	0.004 (0.014)	-0.034* (0.017)
Spreads(-1) *ratings	-0.027* (0.008)	0.041** (0.011)	-0.013** (0.004)	-0.067** (0.027)	0.212 (0.123)	-0.014** (0.004)
$E_t(Primary_{t+4})$ *ratings	-0.011** (0.002)	0.019** (0.007)	0.001 (0.001)	0.025* (0.013)	-0.056** (0.018)	$7.97x10^{-4}$ (0.004)
$E_t(Debt_{t+4})$* ratings	$-7.84x10^{-5}$ (0.001)	-0.002 (0.004)	-0.003** (0.001)	0.003 (0.003)	-0.009 (0.029)	-0.007** (0.001)
$E_t(Debt^2_{t+4})$* ratings	$-1.54x10^{-6}$ ($8.13x10^{-6}$)	$-4.04x10^{-5}$ ($1.89x10^{-6}$)	$1.16x10^{-5}$** $4.05x10^{-6}$)	$-1.80x10^{-5}$ ($2.27x10^{-5}$)	$-4.78x10^{-5}$ ($1.32x10^{-4}$)	$4.82x10^{-4}$** ($8.00x10^{-6}$)
Inflation *ratings	0.011* (0.005)	-0.003 (0.009)	0.014** (0.002)	-0.024 (0.014)	-0.005 (0.027)	0.021** (0.007)
Real GDP growth *ratings	0.009* (0.004)	-0.003 (0.008)	-0.003 (0.002)	-0.004 (0.004)	-0.032* (0.013)	-0.009* (0.004)
Consumer Confidence *ratings	0.002 (0.002)	-0.006** (0.001)	-0.004** ($6.42x10^{-4}$)	$-1.38x10^{-4}$ (0.002)	0.004 (0.009)	-0.002 (0.001)
Bank credit-to-gdp *ratings	$-7.28x10^{-4}$ ($4.64x10^{-4}$)	0.004** (0.001)	$4.13x10^{-4}$* ($2.03x10^{-4}$)	$-6.63x10^{-4}$ ($7.29x10^{-4}$)	-0.003 (0.008)	0.001** ($3.77x10^{-4}$)
VIX*ratings	0.003** (0.001)	0.006** (0.002)	$9.55x10^{-4}$ ($9.36x10^{-4}$)	0.001 (0.002)	$-9.65x10^{-4}$ (0.002)	0.005** (0.002)
Idiosyncratic Volatility *ratings	-0.004 (0.003)	$-4.93x10^{-4}$ (0.001)	0.009** (0.002)	0.005 (0.004)	-0.006 (0.007)	0.011** (0.003)
Cross section FE	Yes	Yes	Yes	Yes	Yes	Yes
Countries included	All countries	All countries	All countries	Euro area	Euro area	Euro area
Period	2001Q1 to 2007Q2	2007Q3 to 2009Q1	2009Q2 to 2019Q4	2001Q1 to 2007Q2	2007Q3 to 2009Q1	2009Q2 to 2019Q4
Obs.	590	200	1149	278	77	473
Adj. R-squared	0.934	0.963	0.964	0.847	0.922	0.933
Durbin-h	2.120	2.272	2.095	2.367	2.428	2.043

Note: Panel FGLS estimates with fixed effects and robust standard errors (cross-section weights), for specific periods and groups of sovereigns; in particular, the second, third and fourth columns, from the left, present results for all countries, for the period before, during and after the GFC, while the next three columns present results for euro-area countries for the aforementioned periods. Numbers in parentheses refer to standard errors. Asterisks * and ** denote 5% and 1% significance.

Table 5 – Including central banks' government bond purchases (various specifications)				
	(1)	**(2)**	**(3)**	**(4)**
Intercept	0.023 (0.218)	0.126 (0.227)	-0.119 (0.216)	-0.106 (0.218)
Spreads(-1)	0.847** (0.024)	0.835** (0.025)	0.867** (0.023)	0.868** (0.023)
$E_t(Primary_{t+4})$	-0.019 (0.011)	-0.017 (0.011)	-0.027* (0.011)	-0.027* (0.011)
$E_t(Debt_{t+4})$	0.006 (0.005)	0.004 (0.005)	0.006 (0.005)	0.006 (0.005)
$E_t(Debt^2_{t+4})$	$-2.93\text{x}10^{-5}$ ($3.11\text{x}10^{-5}$)	$-2.25\text{x}10^{-5}$ ($3.15\text{x}10^{-5}$)	$-2.24\text{x}10^{-5}$ ($3.28\text{x}10^{-5}$)	$-2.44\text{x}10^{-5}$ ($3.29\text{x}10^{-5}$)
Inflation	0.006 (0.015)	0.007 (0.015)	0.001 (0.015)	0.003 (0.015)
Real GDP growth	0.035** (0.009)	0.034** (0.009)	0.035** (0.010)	0.035** (0.010)
Consumer Confidence	0.008** (0.002)	0.008** (0.002)	0.008** (0.002)	0.008** (0.002)
Bank credit-to-gdp	-0.002 (0.001)	-0.002 (0.001)	-0.001 (0.001)	-0.002 (0.001)
VIX	0.011** (0.004)	0.012** (0.004)	0.013** (0.004)	0.012** (0.004)
Idiosyncratic Volatility	-0.033** (0.013)	-0.036** (0.013)	-0.033* (0.014)	-0.034** (0.013)
Spreads(-1) *ratings	-0.013** (0.003)	-0.012** (0.003)	-0.013** (0.003)	-0.013** (0.003)
$E_t(Primary_{t+4})$ *ratings	0.001 (0.001)	0.001 (0.001)	0.002 (0.001)	0.002 (0.001)
$E_t(Debt_{t+4})$* ratings	-0.003** ($7.72\text{x}10^{-4}$)	-0.002** ($7.51\text{x}10^{-4}$)	-0.002** ($7.64\text{x}10^{-4}$)	-0.003** ($7.98\text{x}10^{-4}$)
$E_t(Debt^2_{t+4})$* ratings	$1.56\text{x}10^{-5}$** ($4.13\text{x}10^{-6}$)	$1.25\text{x}10^{-5}$** ($3.89\text{x}10^{-6}$)	$1.16\text{x}10^{-5}$** ($4.05\text{x}10^{-6}$)	$1.24\text{x}10^{-5}$** ($4.32\text{x}10^{-6}$)
Inflation *ratings	0.015** (0.002)	0.015** (0.002)	0.014** (0.002)	0.014** (0.002)
Real GDP growth *ratings	-0.004* (0.002)	-0.004* (0.002)	-0.003 (0.002)	-0.003 (0.002)
Consumer Confidence*ratings	-0.004** ($6.53\text{x}10^{-4}$)	-0.004** ($6.76\text{x}10^{-4}$)	-0.004** ($6.48\text{x}10^{-4}$)	-0.004** ($6.48\text{x}10^{-4}$)
Bank credit-to-gdp *ratings	$4.27\text{x}10^{-4}$* ($2.13\text{x}10^{-4}$)	$3.25\text{x}10^{-4}$ ($2.15\text{x}10^{-4}$)	$4.34\text{x}10^{-4}$* ($2.12\text{x}10^{-4}$)	$4.29\text{x}10^{-4}$* ($2.14\text{x}10^{-4}$)
VIX*ratings	0.001 ($9.50\text{x}10^{-4}$)	0.001 ($9.49\text{x}10^{-4}$)	$9.62\text{x}10^{-4}$ ($9.36\text{x}10^{-4}$)	$9.35\text{x}10^{-4}$ ($9.36\text{x}10^{-4}$)
Idiosyncratic Volatility *ratings	0.009** (0.002)	0.009** (0.002)	0.009** (0.002)	0.009** (0.002)
CB's gvt bonds as % of GDP	-0.752** (0.228)			
CB's gvt bonds as % of debt		-0.719** (0.228)		
Δ(gvt bonds) / Δ(debt)			$3.84\text{x}10^{-4}$ (0.001)	
Gvt bonds of domestic CB vs. Fed				-0.116 (0.212)
Cross section FE	Yes	Yes	Yes	Yes
Period	2009Q2 to 2019Q4	2009Q2 to 2019Q4	2009Q2 to 2019Q4	2009Q2 to 2019Q4
Obs.	1149	1149	1149	1149
Adj. R-squared	0.964	0.964	0.964	0.964
Durbin-h	2.078	2.073	2.095	2.095

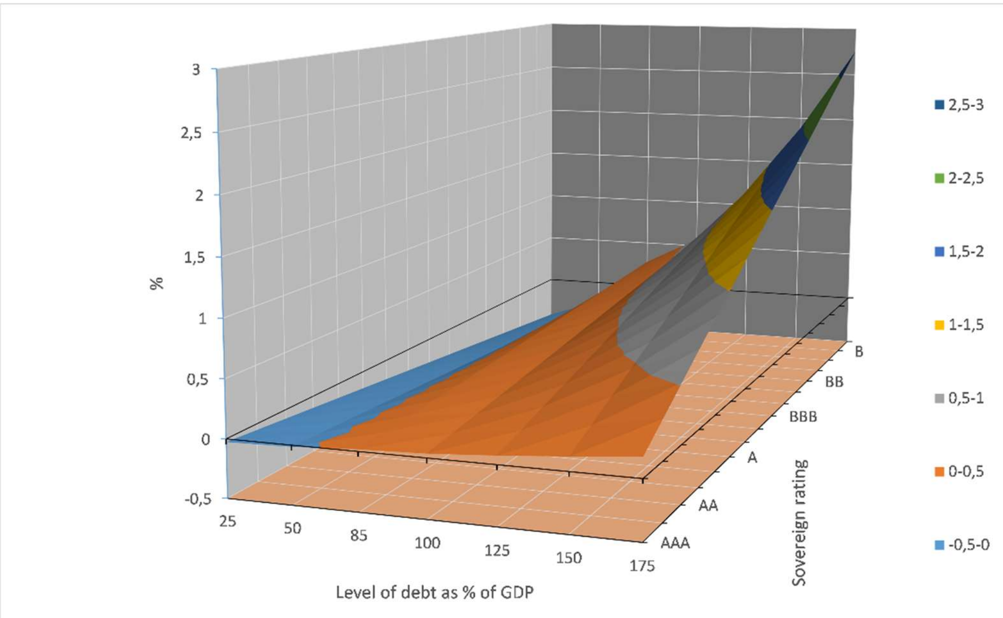
Note: Panel FGLS estimates with fixed effects and robust standard errors (cross-section weights), for specific periods and groups of sovereigns; in particular, the second, third and fourth columns, from the left, present results for all countries, for the period before, during and after the GFC, while the next three columns present results for euro-area countries for the aforementioned periods. Numbers in parentheses refer to standard errors. Asterisks * and ** denote 5% and 1% significance.

Figure 1: Heterogeneous effects of primary fiscal balance on sovereign spreads



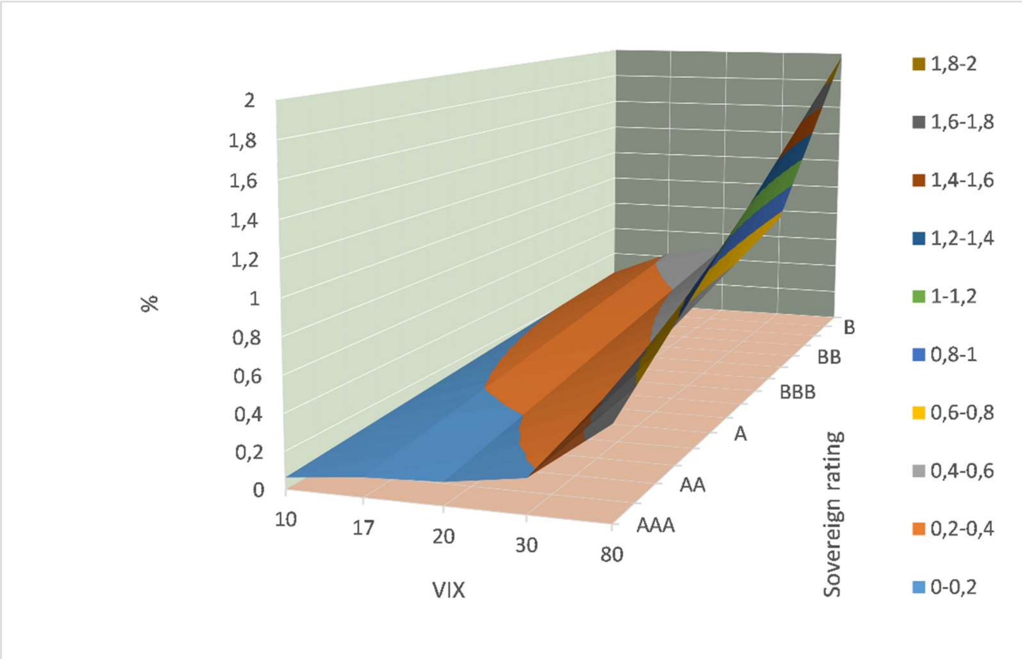
Note: Figure 1 illustrates the contributions of different levels of primary fiscal balance (presented in the x-axis) on sovereign bond spreads (y-axis), classified by the rating of the sovereign (z-axis); negative values of the primary balance correspond to 'primary deficits' and positive values to 'primary surpluses'. The coefficients used for calculating the contributions are the ones presented under model 9, in Table 1. Only coefficients significant at 5% or 1% are used.

Figure 2: Heterogeneous effects of the level of public debt on sovereign spreads



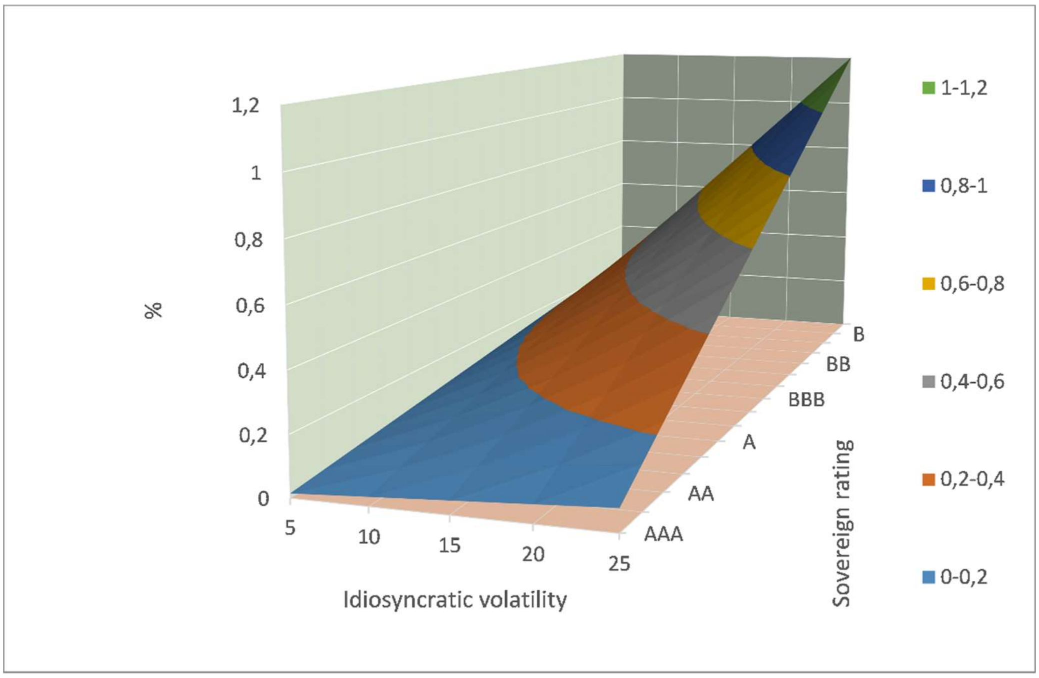
Note: Figure 2 illustrates the contributions of different levels of public debt (presented in the x-axis) on sovereign bond spreads (y-axis), classified by the rating of the sovereign (z-axis), based on model 9 Table 1. Only coefficients significant at 5% or 1% are used.

Figure 3: Heterogeneous effects of VIX



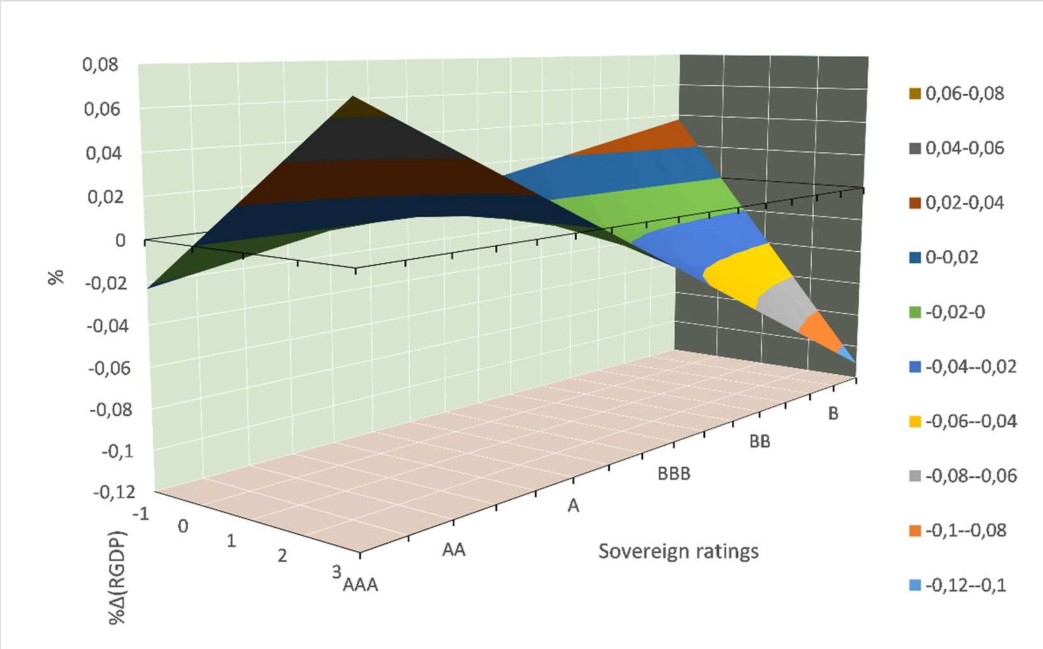
Note: Figure 3 illustrates the contributions of different values of VIX (presented in the x-axis) on sovereign bond spreads (y-axis), classified by the rating of the sovereign (z-axis), based on model 9 Table 1. Only coefficients significant at 5% or 1% are used.

Figure 4: Heterogeneous effects of idiosyncratic volatility



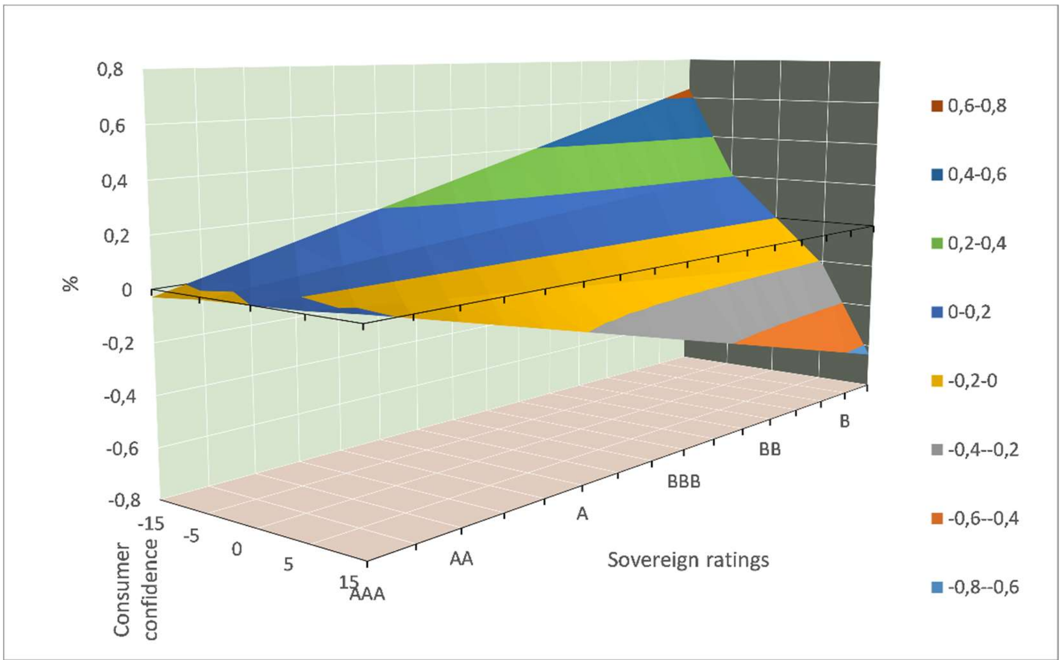
Note: Figure 4 illustrates the contributions of different levels of the idiosyncratic component of equity market volatility (presented in the x-axis) on sovereign bond spreads (y-axis), classified by the rating of the sovereign (z-axis), based on model 9 Table 1. Only coefficients significant at 5% or 1% are used.

Figure 5: Heterogeneous effects of economic growth



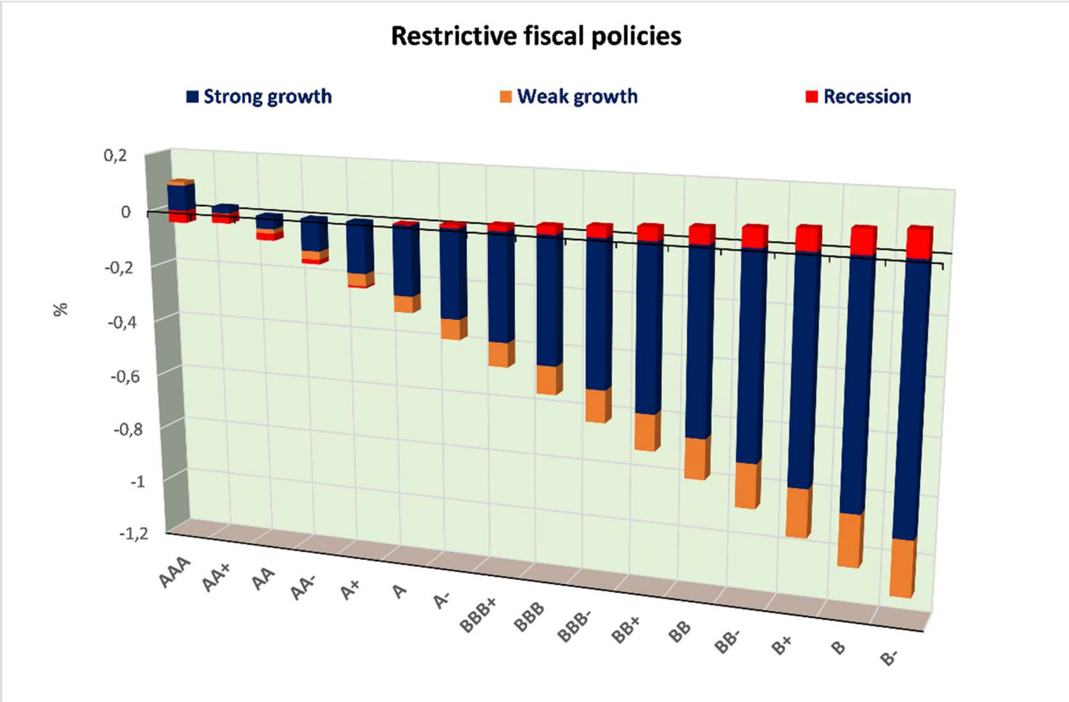
Note: Figure 5 illustrates the contributions of different levels of the real GDP growth rate (presented in the x-axis) on sovereign bond spreads (y-axis), classified by the rating of the sovereign (z-axis), based on model 9 Table 1. Only coefficients significant at 5% or 1% are used.

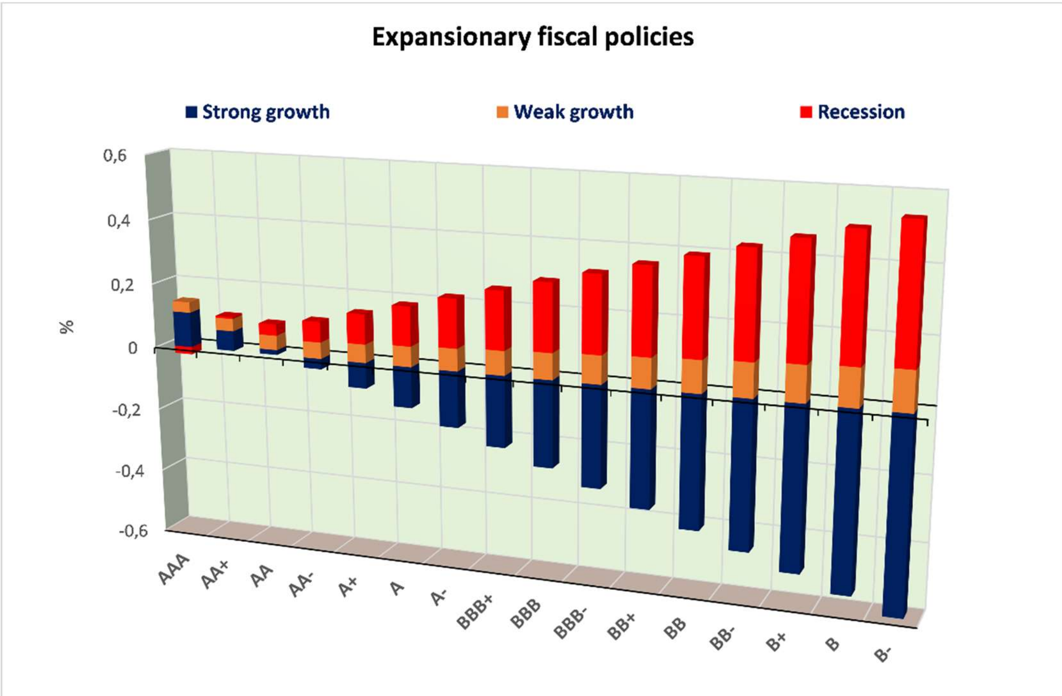
Figure 6: Heterogeneous effects of economic confidence



Note: Figure 5 illustrates the contributions of different levels of consumer confidence (presented in the x-axis) on sovereign bond spreads (y-axis), classified by the rating of the sovereign (z-axis), based on model 9 Table 1. Only coefficients significant at 5% or 1% are used.

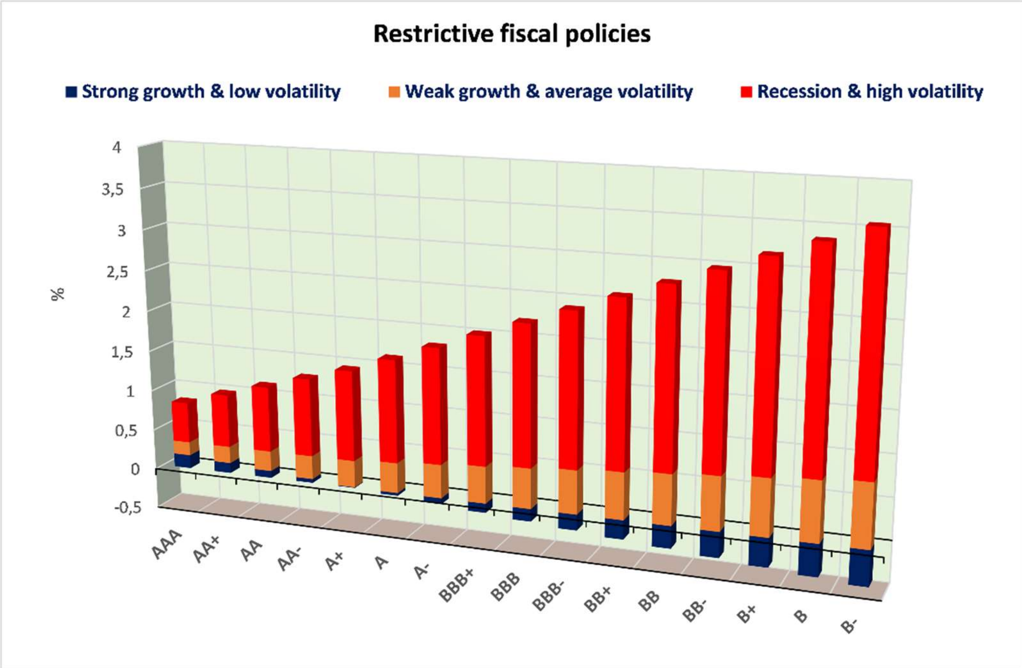
Figure 7: Heterogeneous effects of fiscal policies under different states of growth

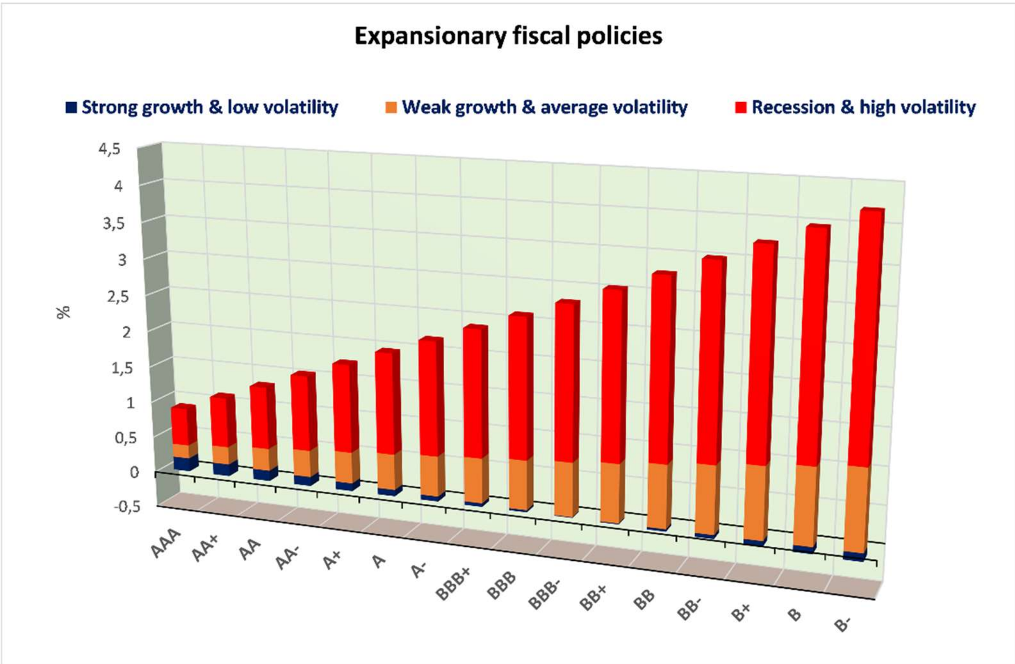




Note: The above charts illustrate the rating-specific contributions on spreads by of a 2.5% of GDP primary surplus (restrictive fiscal policy) or a 2.5% of GDP primary deficit (expansionary fiscal policy), under different scenarios about the path of economic activity. The three hypothetical states of the economy are: strong growth (blue bars), weak growth (orange bars) and recession (red bars). Strong growth is defined as a 3% growth rate in real GDP, combined with strong positive levels of the consumer confidence indicator. Weak growth is defined as a growth rate of real GDP at 1%, combined with low positive levels of the consumer confidence indicator. Finally, the recession is defined as a -1% real GDP growth rate, combined with negative levels of the consumer confidence indicator. The results illustrated in the charts above are based on the estimated coefficients under model 9, of Table 1. Only coefficients significant at 5% or 1% are used.

Figure 8: Heterogeneous effects of fiscal policies under different states of growth & volatility





Note: In the above charts on top of the scenarios of Figure 7, volatility is assumed to follow three different paths: low, average and high. In the 'low volatility' regime, we assume that both the VIX and the idiosyncratic volatilities stand at their low levels of their historical ranges, as defined by of the median of each series minus 1 standard deviation. In the 'average volatility' the level of volatility is equal to the historical median, while in the 'high volatility' regime the value corresponding to the upper 25% of the distribution of each series, is used.