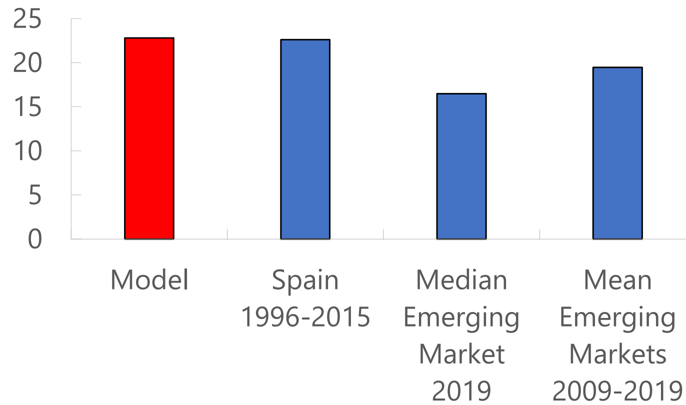
Online Annex 2.1. Model Appendix[1]

The sovereign debt model of Bianchi, Ottonello and Presno (2021), developed in the tradition of Eaton and Gersovitz (1981), Aguiar and Gopinath (2006), and Arellano (2008) helps study the trade-off between supporting the economy out of a recession and the cost of higher sovereign spreads and risk of default. The model features a small open economy with endogenous default, endogenous fiscal policy, with a country subject to exogenous risks and a Keynesian effect of fiscal policy due to nominal rigidities.

The economy is populated by a continuum of ex-ante identical households of measure one. Households consume tradable and nontradable goods and are endowed with an indivisible unit of labor and a stochastic flow of a tradable good. Labor is used to produce the nontradable good using a technology of decreasing returns of scale. Nominal wage rigidities may prevent the labor market from clearing, in which case some households may be unemployed. That idiosyncratic risk of unemployment cannot be insured away. Households cannot save. There is no physical capital in the model.

The existence of nominal frictions in the labor market gives rise to Keynesian demand effects. After negative shocks to tradable endowment, higher government spending can increase employment and output but at the cost of higher external debt and higher sovereign spreads and risk of default. The government collects taxes on income and optimally chooses spending on nontradable goods, external borrowing, and whether to default on its debt or not. In case of default, the government is excluded from international financial markets for a stochastic number of years and households suffer a utility loss which is log-linear on output to match empirical sovereign spreads dynamics. Government borrows from risk neutral foreign investors.

Online Figure 2.1.1. External Public Debt (in percent of GDP)



Source: Staff calculations based on World Bank's Quarterly Public Sector Data.
Notes: External public debt is defined as the stock of general government debt held by external creditors.

The model is calibrated to match external public debt and, in that regard, aims to capture the fraction of debt that is particularly vulnerable to reversals in investor sentiment, a phenomenon that is especially concerning for emerging and frontier economies. The model is consistent with fiscal procyclicality in countries with high sovereign risk, an empirical result also documented by (Cuadra, Sanchez, and Sapriza 2010). Through a similar mechanism, the sovereign default literature has also found that the ability to smooth taxes is limited by the risk of default (Pouzo and Presno, 2020). The model is calibrated to Spain (1996–2015) and is able to closely replicate the dynamics during the 2012–13 crisis. Calibrating the model to Brazil (1996–2019) and Greece (1995–2010) yields similar results. The calibration appears also appropriate for the context of emerging markets pre-pandemic (Online Annex Figure 2 1.1.). Naturally, by being calibrated based on historical evidence, the model may miss some recent economic changes induced by the COVID-19 pandemic.

The dependence of the optimal fiscal response to the initial stock of external debt and the fiscal multiplier is presented in the core text (Figure 2.3).

[1] Prepared by Cristian Alonso (FAD), based on model by Bianchi, Ottonello, and Presno (2021)

The value of credibility is assessed by comparing three alternative scenarios of fiscal consolidation departing from the optimal policy responses for a government without commitment:

- A reduction of government spending by 0.5 percent of GDP in the current year.
- A reduction of government spending by 0.5 percent of GDP in the following year.
- A reduction of government spending by 0.7 percent of GDP in the following year only if nominal GDP is within certain thresholds.

The results are presented and discussed in the main text (see Figure 2.4)

Online Annex 2.2. The Weakened Relation Between Sovereign Spreads and Debt[1]

This empirical analysis investigates whether the pervasive rise in debt-to-GDP ratios and low global interest rates, driven partly by low potential growth and conventional and unconventional monetary policy actions, have resulted in a weakened relationship between spreads and debt ratios and may have increased debt-carrying capacity.

Ample existing evidence points to debt indicators as relevant determinants of sovereign spreads. A large literature identifies fiscal indicators, such as the government deficit and debt levels, that significantly correlate with spreads (e.g., Baldacci et al 2008). The correlation is found to be particularly strong in developing countries with a high share of foreign currency debt (Dell'Erba and others, 2013).[2] There is also evidence of state dependence, whereby the impact of fiscal indicators can increase during periods of stress, as changes in the price of risk can interact with domestic vulnerabilities to amplify the impact on borrowing costs for countries with weaker fiscal positions (Baldacci and Kumar 2010; Jaramillo and Weber 2012). More generally, countries with stronger fundamentals tend to have lower sensitivity to changes in global risk aversion (Csonto and Ivaschenko, 2013). In part for this reason, countries with stronger fundamentals (e.g., advanced economies) are estimated to have higher debt tolerance. Nevertheless, debt levels are also positively associated with sovereign yields in advanced economies (Alper and Forni, 2011; Greenlaw and others, 2013; Ichiue and Shimizu, 2012; Pamies and others, 2021).[3] This is in line with evidence that identifies public debt as "the most important predictor of fiscal crises" in developing countries, and an important predictor also in advanced economies (Moreno Badia and others, 2020).

Low borrowing costs despite pervasive increases in government debt during the last decade point to a possible weakening in the relationship between spreads and debt ratios. Market borrowing rates by emerging economies, both for foreign currency debt (EMBIG spreads) and local currency debt (real long-term bond yields), have remained broadly stable since the Global Financial Crisis, while real borrowing costs for advanced economies (for local currency debt), have steadily declined (Online Annex Figure 2.2.1). Meanwhile, government debt-to-GDP levels have risen across both country groups, leading to a rising interest bill in emerging markets, but declining in advanced economies, where lower effective interest rates outweighed higher debt levels (Online Annex Figure 2.2.2).

These developments bring into question whether the relationship between sovereign bond yields and debt indicators – such as debt levels and debt service bill – has become weaker in recent years, thereby increasing countries' debt-carrying capacity. The analysis distinguishes between: (i) advanced versus emerging economies, (ii) foreign versus local currency sovereign borrowing, and (iii) whether debt indicators matter in absolute terms, or relative to other countries' debt levels.

A fundamentals-based asset valuation model, with time-varying coefficients for debt indicators, is estimated to assess whether yields have become less responsive to debt indicators. In particular, the following fixed effect panel regression is estimated:

$$Ln(R_{i,t}) = \alpha_t \overline{\overline{D}}_t + \beta_t (D_{i,t} - \overline{\overline{D}}_t) + \gamma \boldsymbol{X}_{i,t} + \delta \boldsymbol{Z}_t + u_i + \varepsilon_{i,t}$$

[1] Prepared by Andresa Lagerborg (FAD).

[2] The authors find the correlation in advanced economies to be about one-fifth of that in emerging markets. Furthermore, debt composition is found to matter, corroborating the "original sin hypothesis", whereby effects are amplified by the share of debt denominated in foreign currency and presence of large net foreign liabilities, whereas debt levels are insignificant where most public debt is in local currency.

[3] Several papers argue that this effect is present in Eurozone countries, as a result of monetary union, but not in stand-alone countries (e.g., De Grauwe and Ji, 2013; Dell'Erba and others, 2013).

where $R_{i,t}$ denotes the sovereign borrowing cost or spread (measured in logarithms and multiplied by 100) in country *i* and time period *t*, $D_{i,t}$ denotes the debt-to-GDP ratio (henceforth, absolute level of debt), $\overline{D_t}$ denotes the average of all countries' debt levels at time *t* (henceforth called the global level of debt), and $D_{i,t} - \overline{D_t}$ is the level of debt relative to world average (henceforth, relative debt). $\boldsymbol{X}_{i,t}$ is a vector of country-specific fundamentals, $\boldsymbol{Z}_t$ is a vector of global factors (or time dummies), u_i is the country fixed effect, and $\varepsilon_{i,t}$ is a normally-distributed error term.[4]

Estimating time-invariant coefficients α and β allows to check whether only each country's level of debt matters (when $\alpha = \beta$), whether debt relative to the world's average also explain funding costs ($\alpha < \beta$)[5] or whether other countries' vulnerability affects funding costs ($\alpha > \beta$). Allowing both α_t and β_t to vary over time is equivalent to controlling for time dummies, which account for all possible global factors (including variations in global debt levels).[6]

Spreads and global factors are measured at a monthly frequency, while country-specific fundamentals are their annual values, consistent with their slower-moving nature.[7] The analysis studies both foreign and local currency borrowing costs for emerging markets (which tend to borrow in both currencies) and contrasts domestic currency long-term bond yields for emerging markets versus advanced economies.[8]

Static baseline regressions, for the simplified model that considers only absolute debt levels as commonly done in the literature ($\alpha = \beta$), confirm the finding in the literature that weaker fundamentals – including higher debt levels – are associated with higher funding costs. In particular, sovereign spreads are positively related to countries' debt-to-GDP ratio and negatively related to the primary balance (under certain specifications), confirming the relevance of fiscal fundamentals (Online Annex Table 2.2.1). The analysis also points to the relevance of other macroeconomic fundamentals - whereby higher GDP growth, which is associated with macroeconomic stability and "ability to pay" through a growing denominator effect, and a stronger external position, measured by international reserves and international investment position, are associated with lower sovereign spreads. These results broadly hold both for

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[4] The specification is broadly in line with other studies in the literature (e.g., Dell'Erba and others 2012; October 2018 GFSR Online Annex; April 2020 GFSR Online Annex) with a larger focus on fiscal determinants of spreads. Since long-term local currency government bond yields combine default risk with inflationary expectations, average CPI inflation is always included as a regressor for yields. Additional country-specific factors are included in robustness checks, comprising GDP growth as well as the primary balance, government FX reserves, and international investment position as a share of GDP, obtained from the WEO database. Global factors include global risk aversion, as measured by the VIX, and liquidity measured by US 10-year government bond yields and the federal funds rate.

[5] The extreme case is where only relative levels of debt matter ($\alpha_t = 0$).

[6] When controlling for time dummies in the regression (equivalent to allowing $\alpha_t \neq \beta_t$), the time-varying coefficient on debt-to-GDP is interpretated as the correlation of spreads with "relative" debt levels (since time fixed effects would capture global debt/GDP over time). Alternatively, when assuming that only absolute debt levels matter (i.e., $\alpha_t = \beta_t$) and including global factors such as. the VIX and US funding costs as regressors (instead of time dummies), the coefficient on debt-to-GDP is interpreted as the correlation of spreads with "absolute" debt levels.

[7] This mixed frequency approach is in line with much of the literature (e.g., Csonto and Ivaschenko, 2013). To account for repeated observations for annual variables, standard errors are clustered at the country level. Results are robust to alternative specifications that consider a two-way clustering of standard errors (country-year), a linear interpolation of annual variables, and estimation at yearly frequency

[8] Hard currency sovereign spreads are measured using the J.P. Morgan Emerging Markets Bond Index Global (EMBIG) for an unbalanced panel of 67 countries, consisting mostly of emerging markets, spanning December 1997 to May 2021. The EMBIG measures averages of the spread (with respect to US Treasury) on foreign currency denominated debt weighted by the outstanding share of debt by relevant maturity. Domestic currency 10-year sovereign bond yields are obtained from Datastream for an unbalanced panel of 35 advanced economies, 27 emerging markets, and 6 low-income developing countries spanning January 1980 to May 2021.

advanced economies' local currency borrowing as well as for emerging economies' foreign currency borrowing. Results are also broadly robust to capturing global factors through time dummies or by including the VIX, US long-term government bond yields, and the federal funds rate.

Regression tests reveal that both the global level of debt and the country's own debt relative to the global average matter for the pricing of emerging market funding costs ($\alpha \neq \beta \neq 0$). Over the full-time sample covered by the analysis, the sensitivity of spreads to the relative level of debt of each country has exceeded the sensitivity to the global debt level ($\alpha < \beta$) (Online Annex Table 2.2.1, column 3). As a result, an emerging market's cost of funding would have tended to fall if the country's debt was unchanged but global debt increased. This may be because countries have been evaluated relative to each other, for instance by rating agencies (*Global Financial Stability Report October 2019*). However, in the early part of the sample (prior to 2008), which includes the emerging market crises of the 1990s, the sensitivity of EM spreads to the world average level of debt was higher than to each country's relative level of debt ($\alpha > \beta$) (Online Annex Table 2.2.1, column 4).

Dynamic regressions point toward a weakening relationship between local currency bond yields and government debt levels in recent years. Time-varying coefficients on the effect of government debt reveal evidence of changing relationships (Online Annex Figure 2.2.3). Assuming only absolute debt levels matter (i.e. $\alpha_t = \beta_t$), the correlation of spreads with countries' debt-to-GDP ratios is estimated to have weakened across both emerging and advanced economies, reaching historically low levels. Accounting for all possible global factors (including global debt levels) through time dummies (i.e. allowing $\alpha_t \neq \beta_t$), the correlation of spreads with countries' relative debt is also found to have weakened. The estimated weakening relationship is robust to controlling for country-specific macroeconomic fundamentals (bottom panel), where the correlation for advanced economies shifts up into positive territory.

Foreign currency EMBIG bond spreads in emerging markets also show a weakening relation with absolute debt levels, but no such evidence is detected for relative debt. The correlation between countries' absolute debt levels and EMBIG spreads has fallen since 2012, accounting for global risk aversion and liquidity (Online Annex Figure 2.2.3, left charts). Accounting for all possible global factors (including average absolute debt levels) through time dummies, the correlation between countries' relative debt levels and EMBIG spreads appears to have increased steadily since 2008 and remained stable once other macroeconomic fundamentals are accounted for (Online Annex Figure 2.2.3, right charts), showing no evidence of a weakening relationship.

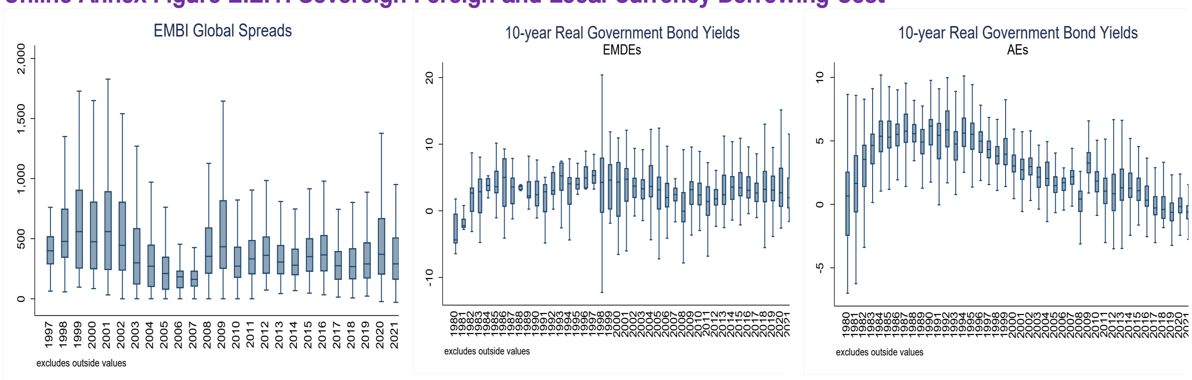
The weakening relationship between sovereign spreads and debt levels should be interpreted with caution. Benign global financing conditions such as low risk aversion and interest rates, if reversed, could cause borrowing costs to rise across the board, leading to sharp increases in debt service costs especially in countries with high debt levels. And while debt appears to matter less than a decade ago in determining spreads, higher debt levels (and weaker fundamentals) relative to other countries still translate into higher government borrowing costs; this seems to be particularly important for the pricing of foreign currency borrowing. Moreover, countries should remain wary of potential interaction effects and state dependence in the correlation between debt levels and sovereign spreads. The drop in the correlation since the global financial crisis coincides with a period of ample global liquidity and could reverse should liquidity reduce. These results also serve as a "reminder that, even in an environment of persistently low rates, more solid fundamentals allow governments to benefit from lower borrowing costs" (Pamies and others, 2021).

Results are robust to various changes in the specification of the model.[9] Results are broadly robust to: (i) regressing spreads (relative to the US) rather than yields; (ii) estimating regressions at a yearly frequency; controlling for quantitative easing by the Fed and ECB (measured using IFS data on central bank claims

[9] These robustness checks are available from the author upon request.

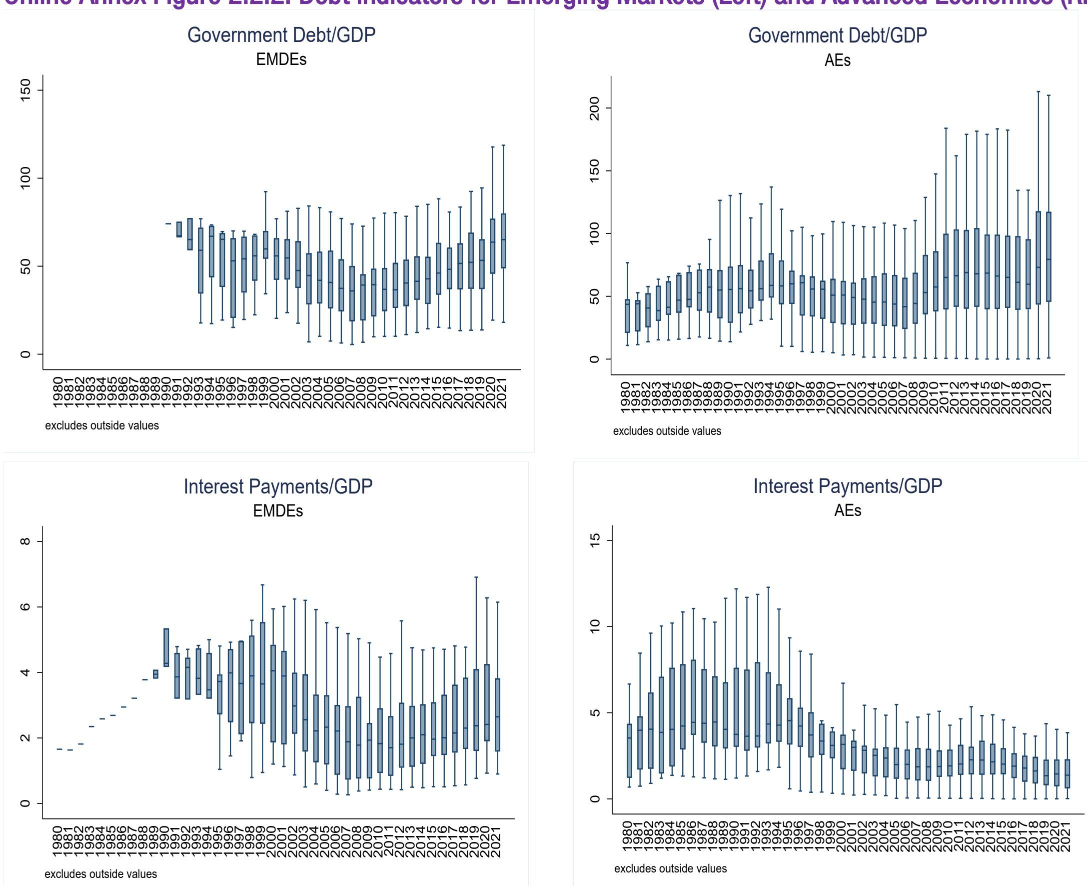
on domestic government debt as a share of US GDP); controlling for additional macro-fiscal variables (e.g., short-term interest rates and domestic bank holdings of government bonds); dropping outlier observations (e.g., where borrowing costs exceed one standard deviation above the mean); and using forward instead of actual values of macro-fiscal variables.[10]

Online Annex Figure 2.2.1. Sovereign Foreign and Local Currency Borrowing Cost



Sources: JP Morgan; Datastream; WEO database; and IMF staff calculations

Online Annex Figure 2.2.2. Debt Indicators for Emerging Markets (Left) and Advanced Economies (Right)



Sources: JP Morgan; Datastream; WEO database; and IMF staff calculations

[10] This proxies for an idea pioneered by Laubach (2009), to correct for endogeneity by using forecasted values of macro-fiscal variables rather than actual values, which has also been found to increase the size of the effect of fiscal variables.

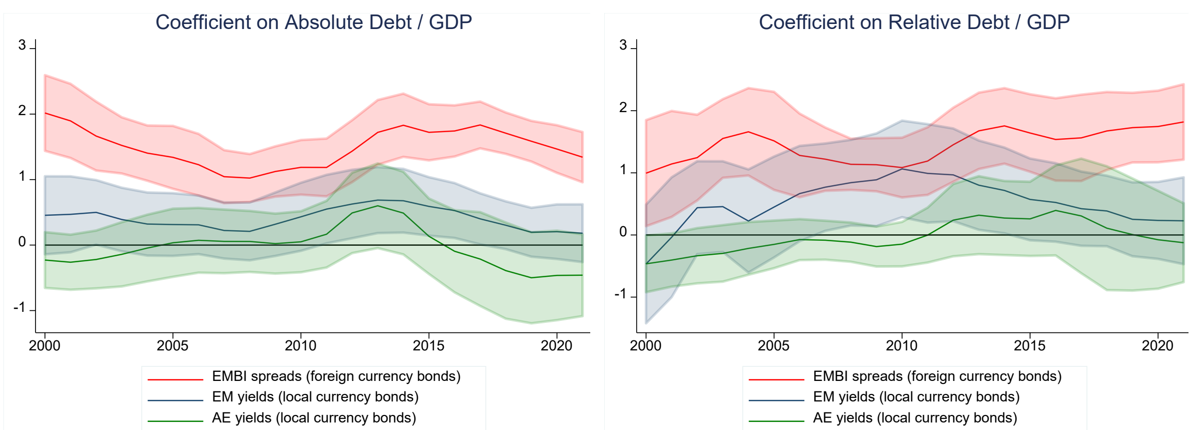
Online Annex Table 2.2.1. Panel Fixed Effect Regressions for Sovereign Spreads–Relation to Debt Levels

	EMDEs				AEs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Time sample	Full	Full	Full	< 2008	Full	Full	< 2012
	Ln(EMBI)	Ln(EMBI)	Ln(EMBI)	Ln(EMBI)	Ln(Yield)	Ln(Yield)	Ln(Yield)
Government debt (% of GDP)	1.57***	1.40***			0.54	0.17	0.43*
	(0.24)	(0.22)			(0.43)	(0.37)	(0.23)
Relative government debt (% of GDP)			1.43***	1.74***			
			(0.23)	(0.35)			
Global average government debt (% of GDP)			1.14***	4.42***			
			(0.38)	(0.48)			
Av. CPI inflation (%)	-0.00***	-0.00***	-0.00***	1.31**	0.33	2.61	2.47***
	(0.00)	(0.00)	(0.00)	(0.60)	(1.93)	(1.74)	(0.84)
Real GDP growth (%)	-2.61***	-2.63***	-2.63***	-0.74	-3.54***	-3.05***	-2.46***
	(0.72)	(0.55)	(0.55)	(0.89)	(1.17)	(0.95)	(0.63)
Primary balance (% of GDP)	-1.59	-0.28	-0.37	0.44	-0.99	-0.78	-1.17**
	(1.18)	(1.21)	(1.15)	(1.67)	(1.14)	(1.06)	(0.44)
FX Reserves (% of GDP)	-0.75	-1.43**	-1.47**	-1.12	-0.59	-0.85*	-0.39**
	(0.52)	(0.63)	(0.60)	(0.69)	(0.53)	(0.48)	(0.19)
IIP (% of GDP)	-0.24**	-0.20*	-0.21*	0.41	0.13	-0.01	0.05
	(0.11)	(0.11)	(0.11)	(0.46)	(0.10)	(0.11)	(0.05)
Ln(VIX)		0.51***	0.52***	0.51***		0.25***	0.10***
		(0.05)	(0.06)	(0.11)		(0.05)	(0.03)
Ln(US long-term bond yield)		39.97***	38.22***	17.12		177.53***	92.91***
		(7.08)	(6.97)	(18.54)		(11.70)	(5.71)
Ln(US federal funds rate)		-0.10***	-0.09***	0.16***		-0.17***	-0.01
		(0.02)	(0.01)	(0.04)		(0.02)	(0.01)
Constant	560.15***	332.77***	346.77***	158.91	231.23***	-178.61***	-30.97*
	(27.95)	(27.25)	(27.99)	(94.02)	(47.51)	(41.48)	(16.23)
Observations	9,964	9,872	9,872	2,596	9,146	9,123	5,927
R-squared	0.57	0.45	0.45	0.67	0.76	0.63	0.63
No. countries	59	59	59	34	33	33	32
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	No	No	No	Yes	No	No

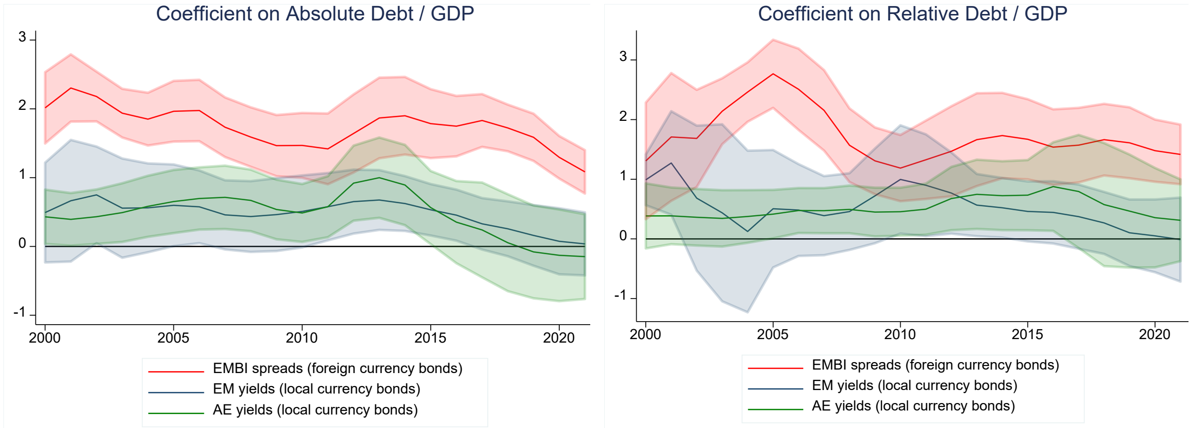
Source: J.P. Morgan; Datastream; WEO database; and IMF staff calculations.
Notes: Standard errors shown in parenthesis are clustered at country level. *, **, and *** respectively denote coefficient significance at the 90, 95, and 99 percent.

Online Annex Figure 2.2.3. Time-Varying Correlation between Sovereign Spreads and Debt Levels

Estimations without Country-Specific Macroeconomic Controls (Top Panel)



Estimations with Country-Specific Macroeconomic Controls (Bottom Panel)



Source: J.P. Morgan; Datastream; WEO database; and IMF staff calculations.
Notes: Plots present 3-year moving averages of coefficient estimates, where dotted lines depict 90 percent confidence intervals.

Online Annex 2.3. Assessing Unexpected Increases in Debt[1]

Shocks that involve large fiscal support or below-the-line operations that increase the exposure of public sector balance sheets can cause unexpected increases in the stock of public debt. This Annex assesses the main drivers of unexpected jumps in public debt over the past 25 years, for all IMF members. The approach is novel in the sense that, instead of focusing on the historical contribution of macroeconomic, fiscal, and financial variables to actual debt changes (see, for example, Abbas and others, 2011; Flores and others, 2021), the Annex examines the contribution of surprises in the projections of these (right-hand side) variables to surprises in the projected (left-hand side) public debt path. The exercise is restricted to debt surprises with positive values, henceforth called "unexpected increases in debt".

Unexpected Increases in Debt—The Role of Forecast Errors on Debt Components

The contribution of forecast errors in each component of the public debt's law of motion—real interest rates, real growth rates (including automatic stabilizers), cyclically adjusted primary balances (controlling for policy measures), valuation effects associated with real exchange rate movements, and other stock-flow adjustments (SFAs)— is quantified following a two-step econometric approach:

- First, using annual observations (actual and projections) collected from the October vintages of the IMF *World Economic Outlook* (*WEO*) databases released during 1995–2019, the *actual* debt changes over forecast horizons from 1 to 5 years for every reporting country (left-hand side of the equation below) are decomposed into their components (right-hand side of the equation below)[2]:

$$\underbrace{d_N - d_0}_{\text{Actual Debt Changes}} = \underbrace{\sum_{i=1}^{N}\left(\frac{r_i}{1+g_i}\right)d_{i-1}}_{\text{Contribution from Real Interest Rates}} - \underbrace{\sum_{i=1}^{N}\left(\frac{g_i}{1+g_i}\right)d_{i-1} - e_0\sum_{i=1}^{N}\sum_{t=1}^{i}\frac{g_i}{\prod_{t=1}^{i}(1+g_i)}}_{\text{Contribution from Real GDP Growth Rates}} - \underbrace{N(\tau_0 - e_0) - \sum_{i=1}^{N}\sum_{t=1}^{i} m_t}_{\text{Contribution from Primary Balances \& Policy Measures}} + \underbrace{\sum_{i=1}^{N} f_i}_{\text{Contribution from SFAs}}$$

  where *d* is the debt-to-GDP ratio, *r* is the real interest rate (computed as the difference between the average effective nominal interest rate and the GDP deflator), *g* is the real GDP growth rate, τ_0 and e_0 represent revenues and primary expenditures (in percent of GDP) at the *WEO* vintage when the forecast is made, *m* is the effect of policy measures, and *f* are stock-flow adjustments. Combining data on the share of foreign-currency denominated debt from the *WEO* vintages and the IMF Debt Sustainability Analysis (*DSA*) database, the contribution of valuation effects associated with exchange rate movements is further isolated from other stock-flow adjustments (not shown in this equation but discussed in the main text).

- The second stage consists in computing the forecast errors on both sides of the equation above such that the contribution of unexpected changes in individual debt drivers to unexpected debt changes at forecast horizons ranging from *N*=1, …, 5 years is given by:

[1] Prepared by Cristian Alonso (FAD) and Roberto Perrelli (FAD).

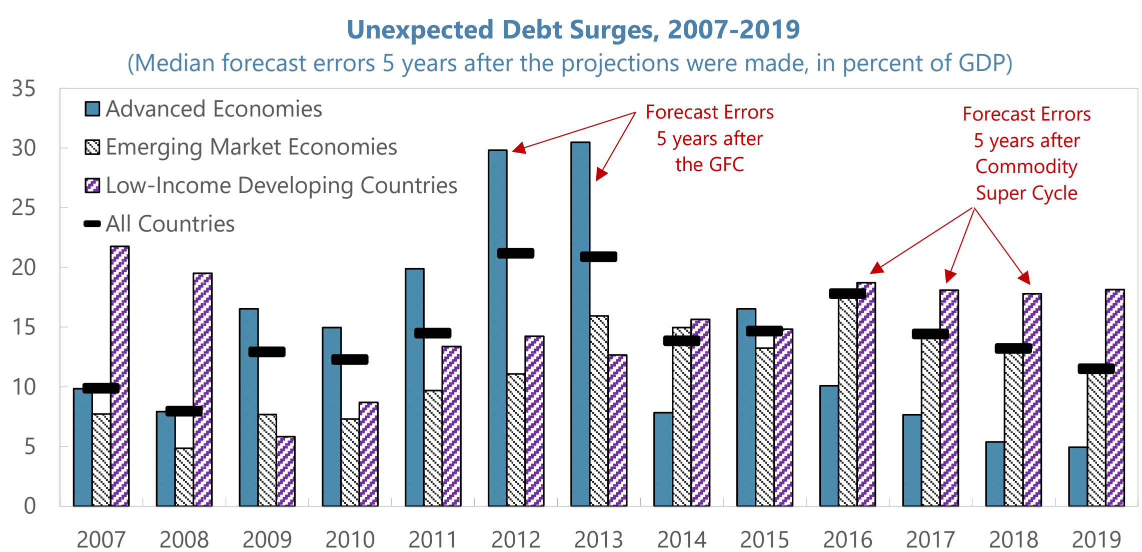
[2] To control for the impact of automatic stabilizers and policy measures on primary fiscal balances, this stage extends the decomposition proposed by Mauro and Zilinsky (2016).

$$\sum_{i=1}^{N}[\Delta d_i - E_0(\Delta d_i)] = \sum_{i=1}^{N}\left[\frac{r_i}{1+g_i}d_{i-1} - E_0\left(\frac{r_i}{1+g_i}d_{i-1}\right)\right] - \sum_{i=1}^{N}\left[\frac{g}{1+g_i}d_{i-1} - E_0\left(\frac{g_i}{1+g_i}d_{i-1}\right)\right] - \sum_{i=1}^{N}\left[e_0\sum_{i=1}^{N}\sum_{t=1}^{i}\frac{g_i}{\Pi_{t=1}^{i}(1+g_i)} - E_0\left(e_0\sum_{i=1}^{N}\sum_{t=1}^{i}\frac{g_i}{\Pi_{t=1}^{i}(1+g_i)}\right)\right] - \sum_{i=1}^{N}[N(\tau_0 - e_0) - E_0(N(\tau_0 - e_0))] - \sum_{i=1}^{N}\left[\sum_{i=1}^{N}\sum_{t=1}^{i}m_t - E_0\left(\sum_{i=1}^{N}\sum_{t=1}^{i}m_t\right)\right] + \sum_{i=1}^{N}[f_i - E(f_i)]$$

where E_0 denotes the expected value of a given variable at the *WEO* vintage when the forecast is made and the remainder terms are as explained earlier. While the computation is made for both negative and positive debt forecast errors, the analysis focuses only on the latter.

Considering all IMF members, the median unanticipated increase in debt at the longest forecast horizon (5 years) was 13.6 percent of GDP, with the median surprise in low income and developing countries (16.5 percent of GDP) being higher than in emerging markets (13.4 percent of GDP) and in advanced economies (12.3 percent of GDP). Given their lower stock of debt, forecast errors were larger in absolute and relative terms for low income and developing economies (Figure 2.6 of the main text). Moreover, the analysis suggests that unexpected increases in debt are bigger following large-scale shocks (e.g., global financial crisis) and turning points in business cycles (e.g., end of commodity super cycle), as illustrated in Online Annex Figure 2.3.1.

Online Annex Figure 2.3.1. Unexpected Increase in Debt, Global Financial Crisis, and the End of the Commodity Super Cycle *(Based on 5-year ahead forecasts, in percent of GDP)*



Sources: IMF, World Economic Outlook database; and IMF staff estimates.

Stress Tests Effectiveness in Anticipating Debt Surges

Box 2.1 presents the first systematic assessment of the capacity of stress tests to flag vulnerabilities and/or anticipate large episodes of debt jumps, leveraging on sensitivity analyses available in the Fiscal Sustainability Reports and/or Debt Sustainability Monitor presented by the European Commission as well as the IMF's Debt Sustainability Analysis (*DSA*) database.[3] The exercise compares the projected debt changes resulting from each stress test with the debt forecast errors due to surprises in the corresponding debt driver as recorded in the *WEO* vintages (Online Annex Table 2.3.1).[4]

Overall, individual stress tests tend to perform better in shorter than longer horizons and in advanced and emerging economies than in low income developing countries (see discussion in Box 2.1). Interest-rate shocks seem less informative in the presence of underperforming nominal GDP deflators. Importantly, combined stress tests and probability-based approaches seem more informative for this analysis. Indeed, the combined shock in the IMF's *DSAs* for advanced economies and emerging markets anticipated about 82 percent of the episodes of debt jumps in the short run and 65 percent over the medium term. By the same token, stress tests designed to capture tail-risk shocks proved informative during the pandemic. For example, United Kindgom's 2017 fiscal risks report identified vulnerabilitoies emerging from synchronized worsening of domestic and global economic and financial conditions as a low probability event that could have very high impact on public sector net debt (OBR, 2017). Similarly, the Netherlands has developed a model aiming to quantify the impact of extreme shocks (CPB, 2020).

Online Annex Table 2.3.1. Number of DSAs for which Each Driver Positively Contributed to the Debt Projection Errors

	Short Term			Medium Term		
	MAC	**LIC**	**EC**	**MAC**	**LIC**	**EC**
Growth	228	161 169	68 37	147	203 203	47 -
Real Interest Rate	197	-	40 16	139	-	37 -
Exchange Rate	231	111	42	203	177	-
Primary Balance	213	115	-	158	128	-
Stock-Flow Adjustments	224	172	-	147	195	-
All	294	180	11	211	250	-

Notes: MAC: IMF Market Access Country. LIC: IMF Low-Income Country. EC: European Commission. Short (medium) term corresponds to a time horizon of 1–2 (3–5) years.
The sample covers 74 countries under the IMF's LIC DSA (2007–17), 111 countries under the IMF's MAC DSA (2013–20), and 27 countries under the EC's DSA (2012, 2017–18). The number of DSAs used in the analysis of each stress test in summarized in the following table.
Each entry in the first row of the table represents the number of DSA-years for which growth positively contributed to a debt projection error. The following rows represent the remaining drivers (namely, real interest rate, exchange rate, primary balance, and stock-flow adjustments). The final row shows the number of DSA-years for which there was a positive debt forecast error overall.
Number of DSA-years in the LIC DSA correspond to the temporary (left) and permanent (right) scenarios. For the EC DSAs with stress tests on growth and real interest rate, the number of observations with the standard and enhanced scenarios are shown in the left and right, respectively.

[3] Many countries have also developed their own tools to assess debt sustainability, including by assessing country-specific scenarios. Some examples include Brazil (2020), Honduras (2019), and New Zealand (2021). Previous work has shown that DSAs have missed fiscal risks but are restricted to some countries in well-documented episodes (Guzman and Heymann 2015).

[4] For low-income developing countries, stress tests are calculated in terms of net present value of debt as percent of GDP. To compare them with the debt outturn, we scale them up by the ratio of net present value to nominal value of debt as obtained from the DSA baseline scenario.

Online Annex 2.4. Fiscal Credibility Indicators Using Private Forecasts[1]

The measures of fiscal credibility used in the Chapter make use of official projections and private forecasts for fiscal balance. Official medium-term projections on growth and fiscal paths are collected from countries' annual budget documents as well as mid-year budget reviews or revised budgets, when available (as in Hadzi-Vaskov and others 2021). For private forecasts, Consensus Economic publications and Bloomberg constitute the main data source, available at monthly frequency, for the current year budget balance and the next fiscal year's budget balance. The sample comprises of 43 countries, covering January 1994 to March 2021.[2] Control variables are from the IMF World Economic Outlook database (for instance, real GDP growth, inflation, output gap, public debt ratio, overall and primary fiscal balance), while variables related to fiscal rules and institutions are from the IMF database on fiscal rules and fiscal councils. Financial data related to yields and spreads are from Bloomberg and Datastream.

For each private forecaster *f*, the difference between private forecasts *(p)* and official forecasts *(o)* in terms of fiscal balance *b* forecasted at time *t* for country *i* for the forecast horizon *h* can be denoted as $\delta_{i,t,f}^{(h)}$ where $\delta_{i,t,f}^{(h)} \equiv E_t^o b_{i,t}^{(h)} - E_t^f b_{i,t}^{(h)}$. The first credibility measure focuses on the **gap** between private forecasters' average expectations and official policy target as follows:

$$gap_{i,t}^{(h)} \equiv < \delta_{i,t,f}^{(h)} >_{f \in Forecasters} \equiv E_t^o b_{i,t}^{(h)} - E_t^f b_{i,t}^{(h)}$$

The second fiscal credibility indicator measures the **disagreement** of private forecasts around official government targets (as in Capistrán and Ramos-Francia 2010; Dovern et al. 2012):

$$RMSE_{i,t}^{(h)} = \sqrt{< \left(\delta_{i,t,f}^{(h)}\right)^2 >_{f \in Forecasters}}$$

Cyclical adjustments are introduced to separate disagreement about the macroeconomic environment and about budget aggregates given macroeconomic assumptions. In addition, fixed-horizon forecasts (Dovern et al. (2012)) have been applied to ensure that a fiscal balance forecast is at a constant horizon rather than at a shrinking horizon with the monthly update. Regression results indicate that:

Fiscal rules and frameworks help anchor private expectations by reducing the gap between official projection and private forecast and reducing the disagreement among private forecasters (centered on official targets) – see Online Annex Table 2.4.1 (columns 1 to 10). Government's past fiscal actions affect fiscal credibility, with a larger forecast errors and downward revisions leading to an increase in discrepancy and disagreement among forecasters (Online Annex Table 2.4.1, columns 11 to 14).

Budget balance rules tend to anchor professional expectations that the budget balance will be close to the rule's ceiling. Caselli and Wingender (2021) found that the adoption of EU fiscal rules led to deficits converging toward the 3 percent of GDP limit. Professional forecasters seem to internalize this, as uncertainty on the budget deficit is wider when budgets have deviated from the -3 percent of GDP (Online Annex Figure 2.4.1)

Market-based creditworthiness worsens when the proposed indicators of fiscal credibility deteriorate. CDS spreads are negatively correlated with fiscal credibility (Online Annex Figure 2.4.2).

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[1] Prepared by Gee Hee Hong (FAD).

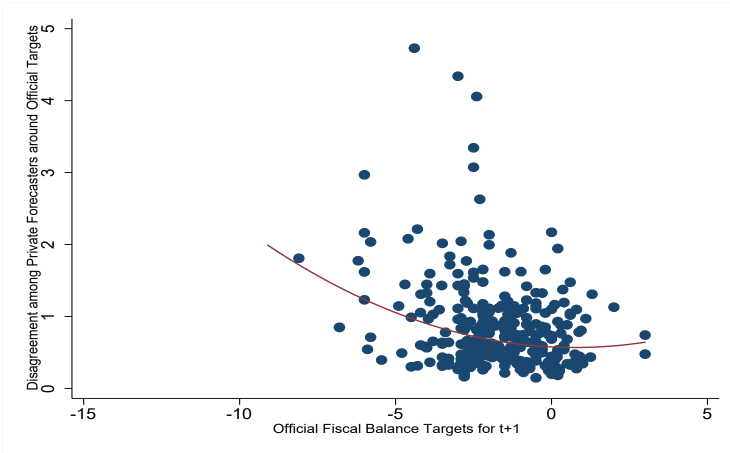
[2] Countries include Austria, Belgium, Denmark, France, Germany, Italy, Luxembourg, Netherlands, Norway, Sweden, Switzerland, Canada, Japan, Finland, Greece, Ireland, Portugal, Spain, UK, USA, Australia, New Zealand, Argentina, Chile, Colombia, Mexico, Peru, Cyprus, Hong Kong SAR, India, Korea, Bulgaria, China, Czech Republic, Slovakia, Estonia, Latvia, Hungary, Lithuania, Croatia, Slovenia, Poland and Romania.

Online Annex Table 2.4.1. Fiscal Rules and Track Records on Fiscal Credibility

VARIABLES	(1) Gap	(2) Gap	(3) Gap	(4) Gap	(5) Gap	(6) Disagreement	(7) Disagreement	(8) Disagreement	(9) Disagreement	(10) Disagreement	(11) Gap	(12) Disagreement	(13) Gap	(14) Disagreement
Market Forecast of RGDP Growth (t+1)	0.0260	-0.00804	-0.0561	-0.0114	-0.00149	0.0500	0.121***	0.190***	0.132***	0.0978**	-0.0382	0.126***	-0.0121	0.104***
	(0.0499)	(0.0473)	(0.0830)	(0.0484)	(0.0495)	(0.0374)	(0.0409)	(0.0586)	(0.0400)	(0.0403)	(0.0509)	(0.0405)	(0.0300)	(0.0311)
RGDP growth (t-1)	0.0391**	0.0479**	0.0710***	0.0504***	0.0484**	-0.0183	-0.0418**	-0.0702***	-0.0456**	-0.0399*	0.0635***	-0.0650***	0.117***	-0.0790***
	(0.0196)	(0.0189)	(0.0233)	(0.0193)	(0.0194)	(0.0204)	(0.0203)	(0.0273)	(0.0201)	(0.0206)	(0.0191)	(0.0216)	(0.0143)	(0.0159)
Primary balance (t-1)	-0.107***	-0.102***	-0.0891***	-0.0910***	-0.0969***	0.0634***	0.0604***	-0.00393	0.0499***	0.0526***	-0.0268	0.0270	-0.0294**	0.0362***
	(0.0213)	(0.0211)	(0.0330)	(0.0219)	(0.0217)	(0.0158)	(0.0165)	(0.0241)	(0.0168)	(0.0170)	(0.0225)	(0.0178)	(0.0126)	(0.0139)
Public debt to GDP (t-1)	0.00560***	0.00367*	0.00544*	0.00330*	0.00335*	-0.00172	0.000984	-0.000878	0.00202	0.00181	0.000641	0.00169	0.00328***	0.000732
	(0.00196)	(0.00190)	(0.00282)	(0.00195)	(0.00197)	(0.00164)	(0.00165)	(0.00203)	(0.00168)	(0.00172)	(0.00184)	(0.00152)	(0.00106)	(0.00125)
Inflation (t-1)	0.0127	-0.00643	0.00942	-0.00248	-0.00206	0.00504	0.0352***	0.0208	0.0321***	0.0297***	-0.118***	0.0188	-0.00513	0.0189***
	(0.0172)	(0.0154)	(0.0586)	(0.0152)	(0.0158)	(0.00933)	(0.00526)	(0.0490)	(0.00550)	(0.00557)	(0.0357)	(0.0299)	(0.0147)	(0.00696)
Budget Balance Rule	1.045***					-1.439***								
	(0.376)					(0.287)								
Debt Rule		0.304**					-0.324***							
		(0.140)					(0.118)							
Fiscal Council			0.161					0.177						
			(0.248)					(0.170)						
Monitoring Body of Fiscal Rule				0.151**					-0.125***					
				(0.0670)					(0.0445)					
Enforcement Body of Fiscal Rule					0.173					-0.240**				
					(0.138)					(0.112)				
Forecast Errors (24m moving average)											0.249***	-0.118***		
											(0.0292)	(0.0231)		
Revision of Forecasts													-0.774***	0.414***
													(0.0249)	(0.0237)
Constant	-1.595*	-0.746	-0.610	-0.905	-0.818	-0.288	-0.484	-1.646***	-0.882***	-0.701*	-1.157	-0.461	-1.670***	-0.193
	(0.851)	(1.310)	(1.147)	(0.773)	(0.800)	(0.571)	(0.614)	(0.593)	(0.323)	(0.373)	(1.129)	(0.578)	(0.494)	(0.338)
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Number of Observations	423	423	241	423	423	299	299	152	299	299	401	285	423	299
Wald Test	231.8	277.5	215.2	234.5	217.9	362.0	492.2	275.8	371.7	378.3	368.4	296.4	1913	900.0

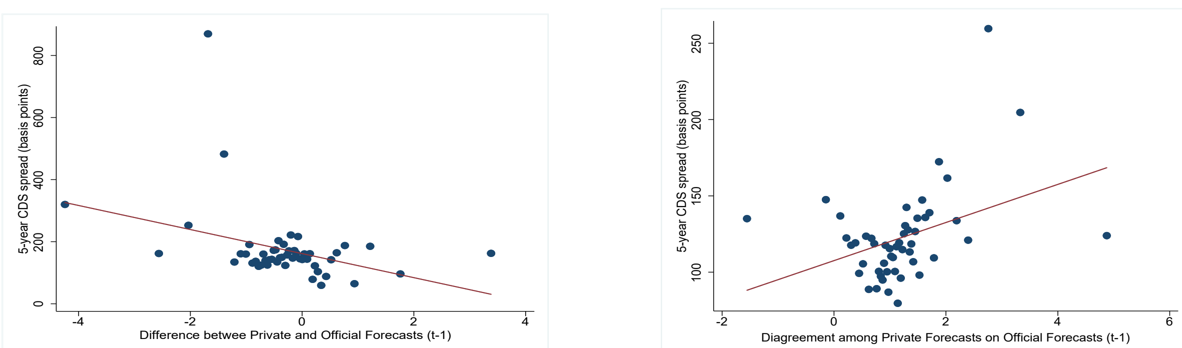
Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, Feasible GLS are run only on the months of announcements of new targets, allowing for heteroskedasticity and AR(1) error structure. Wald chi-squared Test (Chi2) are recorded.
LHS variables 'Gap' is defined as the difference on fiscal balance forecasts between private and official forecasters, and 'Disagreement' is the root mean square deviation of private forecasts around the official target.

Online Annex Figure 2.4.1. Disagreement between Budget Balance Forecasts and Official Projection *(Root mean squared deviation with respect to official budget balance forecasts)*



Note: Scatterplot covers 22 countries in the Euro Area, from 1999 to 2019.

Online Annex Figure 2.4.2. CDS Spreads and Fiscal Credibility



Note: Bin scatter plots grouped the observations into 50 equal bins. Y-axis plots the fitted values of CDS 5-year spread controlling for various macroeconomic variables (lags of real GDP growth, primary balance to GDP, public debt to GDP), year, month and country fixed effects. X-axis plots one-month lag of discrepancy (left) and one-month lag of disagreement (right).

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