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Impact of Sovereign Debt Maturity on Fiscal Sustainability*

António Afonso[†], José Alves[‡], Oļegs Matvejevs[§], Oļegs Tkačevs[¶]

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Abstract

In addition to the significant increase in the public debt ratio over the last decades, another major change has been the substantial increase in the maturity of sovereign borrowing. This study is the first to investigate the impact of the term structure of public debt on fiscal sustainability. We adopt the widely used backward-looking measure of fiscal sustainability – fiscal responsiveness as proposed by Bohn (1998). Using data from De Graeve and Mazzolini (2023) and focusing on a sample of 19 most developed countries, we demonstrate that sovereign borrowing with maturity above 10 years significantly reduces fiscal responsiveness. Conversely, public debt with maturity between 3 and 5 years, which roughly aligns with the electoral cycle in many countries, is associated with the highest responsiveness of the primary balance to public debt. The findings indicate that the increase of long-term public debt since the beginning of this century has contributed to reducing fiscal responsiveness by half. Further analysis indicates that unconventional monetary policy, by suppressing yields at longer maturities, has likely played a key role in the discovered relationship. However, monetary easing has not been the sole factor explaining the negative impact of longer maturity of public debt on fiscal sustainability.

JEL codes: E62, C23, H30, H62, H63.

Keywords: fiscal sustainability, public debt, debt maturity, interest rate.

*The opinions expressed herein are those of the authors and do not necessarily reflect those of the authors' employers. Any remaining errors are the authors' sole responsibility.

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1 Introduction

The ability of a government to borrow easily and at a low cost is a crucial tool for ensuring the provision of public goods and services in optimal quantities without necessitating pro-cyclical adjustments in response to adverse economic shocks. However, when public debt increases overly rapidly or reaches excessive levels, it brings several negative consequences: concerns over public debt sustainability intensify, interest rates, and thus interest payments, rise, and fiscal space contracts, thereby limiting a government's capacity to maintain the provision of public services at optimal levels.

This issue is particularly pressing today, given the unprecedented rise in public debt over recent decades. In less than fifteen years, the global stock of public debt has nearly doubled, growing from 51 to 97 trillion US dollars.[1]The bulk of this debt surge has occurred in developed countries, which, despite their high debt levels, do not currently face the risk of default. One potential explanation lies in the changing maturity structure of public debt, which differs significantly from past decades. Over time, a marked shift of sovereign obligations towards longer maturities has occured. In the Euro Area, for example, the share of long-term debt[2] has risen from 6% in 1995 to more than 20% today. With the exception of the US, this shift has been widespread across major developed economies, with the weighted average maturity of public debt increasing almost continuously.[3]

This study represents the first comprehensive analysis of the impact of sovereign debt maturity on fiscal sustainability. Fiscal sustainability, is measured using fiscal responsiveness estimated from fiscal reaction functions, following the approach from Bohn (1998). Fiscal responsiveness refers to the reaction of primary budget balance to changes in the debt-to-GDP ratio and is widely recognized as the most established backward-looking measure of fiscal sustainability in the literature. Using a sample of 19 highly developed countries for the period from 1995 to 2020, we estimate fiscal responsiveness while accounting for its relationship with the maturity structure of sovereign debt, utilizing a novel dataset by De Graeve and Mazzolini (2023). This dataset provides detailed information on both the face and market values of government debt across various maturity categories. Our analysis focuses on two key measures of the maturity structure: the share of debt with a maturity exceeding 10 years and the weighted average maturity.

The results indicate that sovereign debt with maturities between 1 and 10 years, particularly

[1] UN GCRG (2024)
[2] We classify sovereign debt of maturity of more than 10 years as long-term.
[3] De Graeve and Mazzolini (2023). We illustrate these two facts in Figure 1 and Figure B.1

those in the 3 to 5-year range, has a positive effect on fiscal responsiveness, meaning it is associated with improvements in the government's budget balance as debt levels increase. In contrast, long-term debt, especially with maturities exceeding 10 years, is linked to reduced fiscal responsiveness. A back-on-the-envelope calculation suggests that when half of the debt has a maturity of 10 years or more, fiscal responsiveness approaches zero. Similarly, the primary balance's response to public debt becomes negligible when the weighted average maturity of public debt reaches approximately 14 years. Even when fiscal responsiveness remains slightly positive, public debt converges to a higher level in the medium term. However, we find that the adverse effect of long-term debt maturities on fiscal responsiveness weakens when interest rates are higher.

In the aftermath of the Great Recession, central banks embarked on quantitative easing aimed at lowering long-term interest rates. This policy led to a flattening yield curve, thereby enhancing the attractiveness of long-term borrowing. This, in turn, incentivised fiscal authorities to issue public debt with longer maturities. To investigate whether this yield curve flattening explains the observed decrease in fiscal responsiveness, we employ several methods. First, we examine whether the relationship holds prior to the initiation of quantitative easing. Second, we test whether controlling for the yield curve slope affects the significance of the impact of debt maturities. Lastly, we apply an instrumental variable approach. We find that part of the decrease in fiscal responsiveness due to the shift of the term structure of public debt can indeed be explained by the flattening of the yield curve. At the same time, we provide evidence that even controlling for a change in the slope of the yield curve, increasing maturity of public borrowing reduces fiscal responsiveness, probably due to other factors whose investigation is beyond the scope of this paper.

An important implication of our study is that the current maturity of public debt in developed countries being substantially longer than at any point in history provides governments with greater fiscal space and reduces the pressure to address government deficits in response to rising debt-to-GDP ratios. While this may allow for more countercyclical fiscal policies as interest rates are low, this effect is smaller once interest rates rise, which is already happening now. It also suggests that reducing public debt ratios to moderate levels will take considerably longer. Additionally, while unconventional monetary policies likely contributed to the extension of debt maturities and the associated decline in fiscal responsiveness, our results do not support the conclusion that central bank actions alone have led to a deterioration in fiscal sustainability.

The rest of the paper is structured as follows. The following section reviews relevant literature

and identifies existing research gaps. Section 3 explains the methodology employed and the data utilized in this paper. Section 4 presents the findings and provides an interpretation of the results. Finally, Section 5 concludes.

2 Literature review

2.1 Importance of fiscal sustainability

Fiscal sustainability is defined as the ability of the public sector to finance the provision of public goods and maintain welfare state without undermining its financial health. A crucial part of fiscal sustainability in modern economies is the sustainability of public debt. The ability of the government to fulfil its role depends on easy access to finance, which is contingent on the ability to raise public debt. Access to cheap financing for the government depends on investors' confidence that no problems with servicing and repaying public debt arise in the future, in other words, confidence in fiscal sustainability. Therefore, it is crucial to thoroughly understand what factors determine and influence fiscal sustainability, and extensive literature exists that studies fiscal sustainability and its determinants.

Despite extensive research, there is no single established measure of fiscal sustainability. Approaches to determine whether the government will be able to service and repay its debt fall into two categories: forward-looking, which assesses future income and spending commitments, while also assessing whether they lead to an explosive debt path or not, and backward-looking, which evaluates past budget balance trends. These approaches are discussed in depth by Debrun et al. (2019).

Forward-looking approaches project future fiscal outcomes based on current policies and economic assumptions. This perspective on fiscal sustainability posits that the present value of future primary surpluses must equate to the current level of debt. Blanchard et al. (1990) demonstrated that a government's debt trajectory must align with its anticipated revenue and expenditure plans to ensure sustainability. This methodology offers a thorough perspective on fiscal sustainability due to its ability to incorporate factors that will change in the future in a pre-determined way, such as a demographic transition and / or long-term fiscal commitments. Auerbach et al. (1991) developed a method to assess the long-term fiscal burden across different generations accounting for the demographic situation. By considering a broad spectrum of economic factors and future projections,

these methods provide a way to comprehensively assess whether contemporary policies sufficiently balance borrowing and repayment over time and do not disproportionately affect future generations. Nevertheless, forward-looking approaches are not without limitations. The inherent uncertainty of future economic conditions and policy impacts renders projections potentially unreliable. Additionally, the sophisticated modelling and assumptions required to evaluate fiscal sustainability from a forward-looking perspective can complicate both the analysis and interpretation.

2.2 Backward-looking perspective on fiscal sustainability

In view of this, a vast amount of literature on fiscal sustainability has focused on the backward-looking perspective. Backward-looking tests have been utilized to examine whether fiscal variables, such as public debt and budget deficits, are stationary or exhibit mean-reverting behaviour. The seminal work by Hamilton and Flavin (1986) established the foundation for using these tests to analyze the sustainability of fiscal policy. The authors argue that for a government's fiscal policy to be sustainable, government debt should not follow a random walk without drift, indicating that past fiscal policies have not resulted in an explosive debt path.

Another seminal study is Bohn (1998), where he evaluated governmental adjustments in primary budget balances relative to fluctuations in public debt levels. This study demonstrates that U.S. fiscal policy has exhibited long-term sustainability, as evidenced by the government's systematic responses to rising debt levels. However, the seminal contribution of Bohn (1998) is methodological. He has developed a framework for the evaluation of fiscal sustainability using fiscal reaction functions, where sustainability is determined by whether fiscal authorities increase primary balances when the debt-to-GDP ratio is higher.

Bohn (1998) has shown that in order for the fiscal policy to be compatible with the intertemporal budget constrain (IBC), the primary balance of the government budget must be positively and significantly related to the stock of public debt in the previous period.

$$PB_t = \alpha + \beta D_{t-1} + \varepsilon_t \tag{1}$$

According to Bohn (1998), a positive fiscal responsiveness ($\beta > 0$) is a sufficient statistic for fiscal sustainability as it ensures that a rise in public debt is compensated by higher primary balances, which serves as quantitative evidence of the presence of a commitment to prevent public debt from

increasing at an explosive rate. In 2007, Bohn showed that fiscal sustainability is ensured in the presence of fiscal responsiveness to government debt reflected by β even if the cointegration analysis between government revenues and expenditure does not allow to conclude that the two sides of the government budget are cointegrated (Bohn 2007).

Following Bohn's (1998) pioneering analysis of fiscal sustainability through the lens of fiscal reaction functions, a substantial body of literature has expanded, refined, and criticised his framework. Debrun et al. (2019) and Mauro et al. (2015) provide details on public debt sustainability arithmetic and show that the regression is well-specified in levels even if the variables are non-stationary. It has also been demonstrated that besides signalling the compatibility of fiscal policy with the IBC, the magnitude of the fiscal response coefficient is important as it enters the requirement for public debt to be stationary. Thus, public debt is mean reverting if $\beta > \gamma$, where $\gamma = \frac{r-g}{1+g}$, r is interest rate and g is GDP growth rate (see Debrun et al. (2019) for details on public debt sustainability arithmetic and Mauro et al. 2015 for discussion). If this condition is fulfilled, then public debt converges to level d^* defined as $d^* = \frac{-\alpha}{\beta-\gamma^*}$. Higher values of β imply a larger fiscal response to public debt and lead to a lower debt-to-GDP ratio in the longer run.

Many subsequent studies used Bohn's framework to examine debt sustainability in different countries and across different regimes. Greiner et al. (2007) examined fiscal reactions in developed countries with high debt-to-GDP ratios or those failing to meet Maastricht Treaty deficit criteria, yet still displayed fiscal sustainability. Mendoza and Ostry (2008) found that fiscal responsiveness to increasing debt ratios was notably stronger in emerging economies compared to developed economies, and more robust in low-debt countries. Afonso and Jalles (2011) and Afonso et al. (2021) provided additional evidence of Ricardian behaviour among OECD countries, where fiscal authorities improved budget balances in response to rising debt levels. Notably, Afonso et al. (2021) observed that governments were more responsive when the interest rate-growth rate differential was positive.

Ghosh et al. (2013) examined the capacity of public authorities to meet debt obligations while ensuring fiscal sustainability, although they acknowledged the fragility of assuming a constant risk-free interest rate. Debrun and Kinda (2016) discussed this assumption, particularly in light of rising interest rates and their impact on rigid social expenditures, especially in aging advanced economies. Potrafke and Reischmann (2015) highlighted the significance of including fiscal transfers in primary budget balances to ensure sustainability in the U.S. and Germany. Saadaoui et al. (2022) employed

time-varying fiscal reaction functions and threshold approaches for six industrial countries, finding mixed results but supporting sustainability for Sweden and the United Kingdom. The impact of Euro Area membership on debt sustainability has also been explored, with Ghosh et al. (2013) noting that fiscal flexibility within the Eurozone is constrained compared to non-Eurozone countries due to rules designed to stabilize the common currency.

As previously noted, Bohn's approach, being based on the fiscal reaction function, is especially well suited for exploring the role of different factors that affect fiscal responsiveness, because additional factors can be added to the regression of primary balance on public debt. Afonso and Jalles (2017) study the impact of a wide variety of factors on fiscal sustainability. They find evidence for improved fiscal responsiveness if public debt is held by the central bank or if it is easily marketable in capital markets. The interaction between fiscal reaction functions and the business cycle has been examined by Combes et al. (2017), Legrenzi and Milas (2013), and Everaert and Jansen (2018), revealing non-linear fiscal reactions to economic conditions. Legrenzi and Milas (2013) introduced non-linear fiscal reaction functions with endogenous thresholds, providing insights into the fiscal behaviour of peripheral Eurozone economies like Greece.

2.3 Sovereign debt maturity

In the public debate, the maturity structure of public debt is rarely considered as an important factor impacting fiscal sustainability. However, for treasuries the term structure of debt is important for many reasons. Nuerous factors are to be considered when deciding on the maturity of bonds to be issued to finance a government's needs.

First, when a substantial portion of debt matures within a short period, successful refinancing requires that the supply of the newly issued government bonds be met by an equally large demand—i.e., a sufficient number of buyers of government securities. This demand is contingent on the attractiveness of government bonds at the time, which may decline in the event of unforeseen economic shocks, such as the onset of a pandemic or a financial crisis. In such situations, there is a risk that to meet the reduced demand, the government might need to raise the interest rate on public debt, which would have a negative effect on the government budget in the future. To mitigate this risk, it is rational for a sovereign to have a term structure of debt such that the share of debt that needs to be repaid or refinanced every period is low. This is easier to achieve when the maturity of public debt is spread out in time, with some of it having very long maturity.

Second, debt of different maturities has a different required return. Typically, a positive term premium exists, meaning that issuing longer-term debt is more costly. Consequently, if the average maturity of debt is longer, a larger share of it has a higher term premium, and the average interest rate on debt is higher. This, in turn, raises the interest servicing cost as a share of government budget expenditure, relative to a situation where most debt is short-term.The magnitude of this effect depends on the difference between long- and short-term rates, commonly referred to as the slope of the yield curve. Thus, variations in the yield curve slope may significantly influence how governments navigate the trade-off between short- and long-term debt maturities. This is emphasized in Greenwood et al. (2015), who explain that the slope of the yield curve serves as a key signal for debt managers, guiding decisions on whether to issue short- or long-term debt. When the yield curve is steep, governments might favour short-term debt to minimize costs. However, this strategy increases exposure to future rate hikes. Broner et al. (2007) demonstrate that this issue is particularly pertinent for developing economies, where the term premium demanded by markets is high. Faced with a steeper yield curve, they turn to shorter maturities, which in turn increases the share of debt to be refinanced every year, making the government less resilient. Mendoza and Oviedo (2006) emphasize that emerging countries are especially prone to volatile environments, and increasing the maturity of debt would have a positive impact on fiscal sustainability by partially shielding these countries from debt distress in the aftermath of adverse shocks.

Missale and Blanchard (1994) have performed a thorough investigation of the optimal maturity structure of public debt. They posit that a diversified maturity profile can mitigate refinancing risks and stabilize fiscal policy. They contend that governments should balance the advantages of longer maturities with their associated higher costs to formulate a sustainable debt strategy. More recently, Reinhart and Rogoff (2010) investigated the historical interplay between public debt and economic growth, emphasizing the inherent risks associated with high debt levels, particularly when there are shorter debt maturities. Their analysis underscores the critical importance of managing debt maturity as a strategy to mitigate the negative impact of high debt on fiscal sustainability and economic growth. Furthermore, Jaimovich and Panizza (2010) examine the effect of debt maturity on fiscal discipline, concluding that longer debt maturities correlate with reduced fiscal deficits. They emphasize that extending the maturities of debt allows governments to alleviate the necessity for immediate austerity measures, thereby sustaining fiscal stability. Debrun et al. (2019) conclude that countries with longer average debt maturities experience lower fiscal risks and greater stability.

They emphasize the role of prudent debt management strategies in enhancing fiscal sustainability.

Although the possible mechanisms how debt maturity can affect fiscal sustainability has been outlined in the literature, no comprehensive empirical study estimating the impact of the term structure of public debt on fiscal sustainability has been performed. With this study, we address this gap.

3 Methodology and Data

3.1 Methodology

In this study, we examine whether fiscal sustainability is influenced by the maturity structure of public debt. For this purpose, we use the Bohn (1998) framework of fiscal responsiveness and interact the public debt variable with a) the share of long-term public debt (with a maturity of 10 years and higher) and b) the weighted average maturity of the public debt in order to quantify their impact on the magnitude of the fiscal response, denoted by β in equation 1. We also benefit from the availability of granular public debt data and further analyse the impact of debt across various categories by residual maturity: a) less than 1 year, b) 1 to 3 years, c) 3 to 5 years, d) 5 to 10 years, e) 10 to 20 years and f) over 20 years. Additionally, we explore whether the fiscal response coefficient is influenced by the type of agent holding public debt. We also analyse whether the estimated impact of debt maturities varies across different levels of interest rates.

The econometric specification that we use to obtain the panel data estimates is the following.[4]

$$PB_{i,t} = \beta_0 + \beta_1 D_{i,t-1} + \beta_2 D_{i,t-1} * I_{i,t-1} + \beta_3 Y_{i,t} + \gamma_i + \varepsilon_{i,t} \tag{2}$$

where $PB_{i,t}$ is the primary balance-to-GDP ratio in year t and country i, $D_{i,t-1}$ is the public debt-to-GDP ratio lagged by one year, $I_{i,t-1}$ is an interaction variable, $Y_{i,t}$ is the output gap to account for the cyclical component of the primary balance, γ_i is the unobserved country fixed effect and $\varepsilon_{i,t}$ is a standard i.i.d. disturbance term. The coefficient in front of the interaction term β_2 thus signals whether the fiscal response β_1 becomes weaker or stronger due to changes in the public debt profile defined by variable $I_{i,t-1}$ related to the maturity structure of debt – the share of long-term debt or weighted average maturity.

[4]The variables that are included in the fiscal reaction function are integrated of order 1. We tested for the presence of cointegration between these variables and rejected the H0 of no cointegration using a number of panel cointegration test statistics. The results are available upon request.

We estimate Equation 2 in both static and dynamic forms, incorporating a lagged dependent variable on the right-hand side to account for potential inertia in the dynamics of the primary balance. To ensure robustness, we employ various panel econometric techniques. Initially, both the static and dynamic models are estimated using the conventional Ordinary Least Squares (OLS) fixed effects approach. In this estimation, we address potential cross-sectional dependence, which is likely in a panel data context, by using Driscoll and Kraay (1998) standard errors.

It is important to note that applying OLS fixed effects estimation to the dynamic model may yield inconsistent estimates due to the presence of the Nickell (1981) bias. However, this issue becomes less pronounced in panels with a large time dimension (T). Since our sample contains observations for 26 different periods, we do not expect the Nickell bias to significantly affect our results.

Besides OLS, we use several more advanced econometric techniques better suited for panel data. First, we employ the Generalized Method of Moments (GMM) difference estimation technique, as proposed by Arellano and Bond (1991). This method uses lagged levels of the dependent variable as instruments for the lagged dependent variable in the differenced equation. Second, we utilize the GMM system method, developed by Blundell and Bond (1998), which extends the GMM difference estimator by also using lagged differences as instruments for the equation in levels. This approach enhances efficiency when lagged levels serve as weak instruments. Moreover, the GMM system method is preferred over the GMM difference method in cases where primary budget balances exhibit a high degree of persistence. We apply both GMM estimators using a collapsed set from the matrix of available instruments. The decision on the maximum length of lags in each regression considers the performance of the Hansen test of over-identifying restrictions and the absence of second order autocorrelation. We use robust standard errors, adjusted for heteroskedasticity.

Finally, we employ the bias-corrected Least Squares Dummy Variable (LSDVC) dynamic panel estimator, as suggested by Kiviet (1995) and Bruno (2005). This method is particularly advantageous when the number of cross-sections (N) is small and GMM estimators suffer from weak instrument problems, which can lead to imprecise or biased estimates. The validity of GMM estimators heavily depends on the strength of the instruments. Weak instruments can render GMM estimators biased and inefficient, and instrument proliferation—where the number of instruments becomes disproportionately large relative to the number of cross-sections—can result in instability in the estimates.

In contrast, the LSDVC estimator does not rely on the strength of instruments and corrects the bias introduced by the inclusion of the lagged dependent variable in the presence of fixed effects. However, a limitation of this approach is that it does not account for the potential endogeneity of some explanatory variables, such as the output gap in our case. GMM methods, by using internal instruments (e.g., lagged levels or differences), effectively control for endogenous regressors, which is a significant advantage in addressing endogeneity concerns.

We perform a series of robustness checks to ensure the validity of our findings. Specifically, we assess whether our results hold under the exclusion of (a) periods during which central banks implemented quantitative easing measures, (b) the Great Recession and the COVID-19 pandemic, and (c) countries characterized by the highest levels of debt burden.

3.2 Data

The data used for this study is sourced from several datasets. Variables related to the stock of public debt categorized by granular maturity groups and the yield of debt by these groups are taken from De Graeve and Mazzolini (2023). This dataset comprises the following series: sovereign debt by narrow categories of residual maturity (3-month steps for debt with maturity of less than one year, 1-year steps for categories of maturity between 1 and 12 years, and several groups for longer maturities) at face and at market value, (% of GDP), weighted average maturity of outstanding debt (in years), and the average interest rate payable on debt of each maturity group (%), which allows to construct a yield curve for each country representing different interest rates on its debt with different maturity.

Another dataset we use in this study (Arslanalp and Tsuda 2014) comprises detailed information on public debt by investors by providing public debt decomposition into debt held by domestic central banks, domestic commercial banks, domestic non-banks, the foreign official sector, foreign banks, and foreign non-banks. The dataset was updated in 2024.

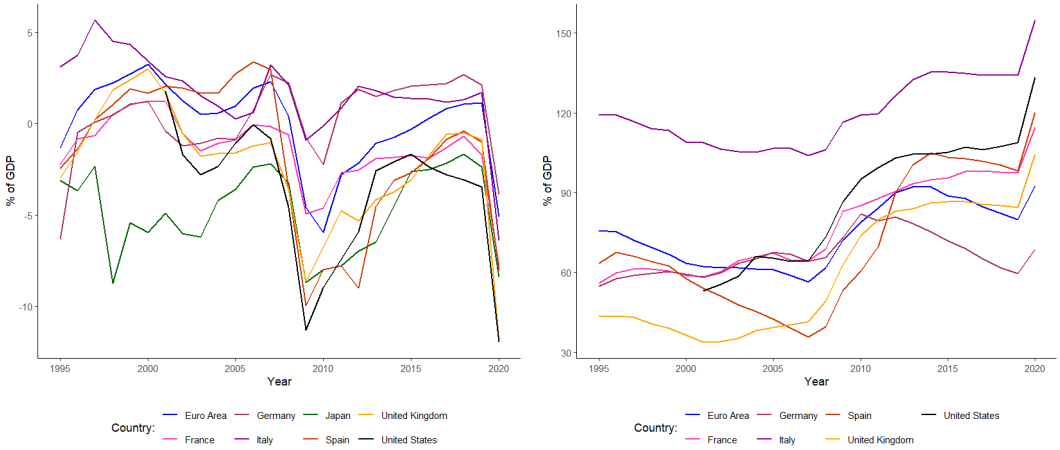
Macroeconomic and fiscal variables (such as output gap, general government primary balance and total public debt) are sourced from the IMF October 2023 World Economic Outlook.[5]

We merge these datasets into an annual panel for the following 19 advanced economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United

[5] https://www.imf.org/en/Publications/WEO/weo-database/2023/October

States. The estimations cover the period from 1995 to 2020, as the dataset for the latest years is incomplete at the moment of writing. Table 1 in Appendix presents the variables employed in our analysis along with their sources, while Table 2 presents the corresponding descriptive statistics.

Figure 1: Primary balance (LHS) and public debt (RHS) in selected advanced countries, 1995-2020

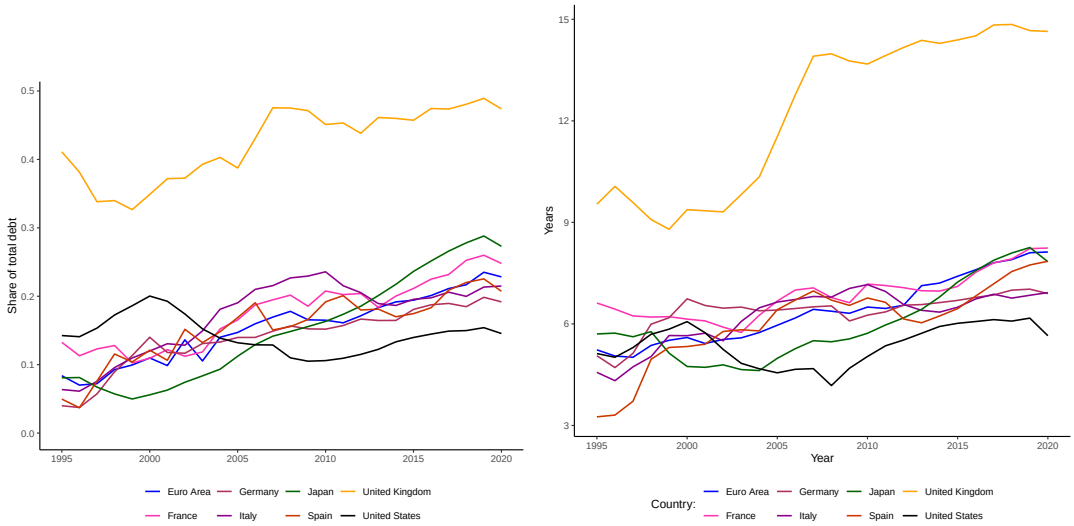


Source: IMF

Figure 1 depicts the primary balance and the debt-to-GDP ratio for selected countries in our sample. Significant deteriorations in primary balances have been observed across all countries during various crises, including the dot-com crisis in the early 2000s, the Great Recession from 2008 to 2011, and the Covid-19 crisis. Prior to the Great Recession, the public debt-to-GDP ratio remained stable; however, it has risen substantially in its aftermath. The Covid-19 crisis further exacerbated this trend, resulting in additional public debt accumulation.

Figure 2 shows the share of long-term debt (with a duration of 10 years and above) and the weighted-average maturity of public debt. Over the past few decades, the term structure of public debt has gradually shifted towards longer maturities in almost all countries. Consequently, the proportion of long-term debt has risen from approximately 10% in 1995 to about 20% in 2020. Historically, the United Kingdom has been an outlier with a particularly high share of long-term debt, yet even in the UK, this share has continued to increase. The upward trend in the share of long-term debt has been especially pronounced in Japan and euro area countries (see also Figure B.1 in Appendix). This resulted in a gradual increase in the weighted average maturity of public debt from around 5 years in 1995 to around 7 years in 2020 (and from 9 to almost 15 in the UK).

Figure 2: Share of long-term debt (LHS) and weighted average maturity of sovereign debt (RHS) in selected advanced countries, 1995-2020



Source: De Graeve and Mazzolini (2023)

4 Results

4.1 Baseline fiscal responsiveness

We begin by establishing the standard Bohn (1998) relationship between primary balance and public debt for a sample of 19 advanced economies. The fiscal responsiveness coefficient is estimated to be around 0.03, indicating that every 10% of GDP of extra sovereign debt is followed by a primary balance improvement of around 0.3% of GDP, assuming that the output gap remains constant. The output gap's effect on the primary balance can operate through two channels. First, automatic stabilizers, which account for the cyclical component of the primary balance, may be at play. Second, the government's discretionary fiscal policy may respond either pro-cyclically or counter-cyclically. Hence we also employ the structural primary balance, which, by design, excludes the effects of automatic stabilizers. Using the structural primary balance, the fiscal responsiveness coefficient remains unchanged, while the coefficient on the output gap decreases as anticipated. Yet it remains positive, reflecting the countercyclical fiscal policies pursued by the governments of countries we focus on in this study.

Regressions with the primary balance as the dependent variable exhibit a higher goodness of fit (i.e. higher R^2). We therefore favour employing the primary balance as the dependent variable in

Table 1: Fiscal responsiveness to total debt

Variable	Primary balance	Structural primary balance
L.Debt	0.0296**	0.0242**
Output gap	0.975***	0.301**
Constant	-1.533	-1.847*
R^2	0.3313	0.0753
Number of observations	468	467
Number of countries	19	19

Notes: The dependent variables are the primary balance and structural primary balance expressed as a percentage of GDP. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. The estimation is conducted using Fixed Effects (FE) estimator. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

all subsequent regressions.[6]

4.2 Impact of the share of long-term debt on fiscal responsiveness

To assess the impact of an increasing proportion of long-term debt on fiscal responsiveness, we add an interaction of the debt variable with the share of long-term debt. We cannot include stocks of debt with different maturity as different independent variables as they are not mutually independent, while the share of long-term debt is not correlated with the debt itself.

Table 2: Impact of the share of long-term debt on fiscal responsiveness

Variable	FE	FE lag	GMM-diff	GMM-sys	LSDVC
L.Primary balance	..	0.537***	0.134	0.776***	0.578***
L.Debt	0.0833***	0.0729***	0.275***	0.114**	0.0697***
L.Debt#L.Longshare	-0.172***	-0.136***	-0.466**	-0.482***	-0.143***
Output gap	1.006***	0.617***	1.206***	0.336	0.588***
Constant	-2.706**	-2.872**		-0.764	
R^2	0.395	0.587	..	..	..
Number of observations	468	468	448	468	468
Number of countries	19	19	19	19	19
Number of instruments	..	..	9	13	..
Hansen test	..	..	0.450	0.115	..
AR(1) test	..	..	0.086	0.087	..
AR(2) test	..	..	0.804	0.373	..

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. Longshare stands for the share of long-term debt (10y and above). The sample comprises annual panel data for 19 developed countries over the period 1995–2020. Estimation is conducted using Fixed Effects (FE), one-step Difference GMM, one-step System GMM, and the bias-corrected Least Squares Dummy Variable (LSDVC) estimators. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

[6]These results using the structural primary balance as the dependent variable are available upon request.

Table 2 presents the estimation results using the methods outlined in the previous section. In addition to the coefficients and their significance levels, the number of countries and observations for each specification are reported. For the GMM regressions, we also provide the number of instruments used, the p-values of the Hansen test for over-identifying restrictions, and the p-values of the AR(1) and AR(2) tests for autocorrelation. The test outcomes largely indicate that the instruments used in the estimation are valid and that no second-order serial correlation is present in the disturbances.

The estimation results confirm a positive and statistically significant relationship between the primary balance and lagged public debt, while also revealing a negative and significant impact of the share of long-term sovereign debt on fiscal responsiveness. Our findings (based on FE estimation) indicate that every additional 10 percentage points of the share of long-term debt within the total sovereign debt stock are associated with a reduced fiscal responsiveness by approximately 0.017% of GDP. The coefficients estimated using GMM and LSDVC corroborate the results obtained from the FE estimations both in terms of their sign and statistical significance .

If we consider the coefficients in front of public debt and its interaction together (see Table 2), we can conclude that the total fiscal responsiveness to public debt reaches zero when the share of long-term debt approaches approximately 50% of the total stock of debt. As shown in Figure 2, except for the United Kingdom, no other country has the share of long-term debt anywhere near to half – for a typical country, this share has gone up from 5-10% at the end of the XX century to the vicinity of 20% by 2020. This means that the increase in the maturity of public debt has contributed to a decrease of fiscal responsiveness by around 0.02 – a notable decrease, but not large enough to push it to zero, which would imply unsustainable debt dynamics.

4.3 Fiscal responsiveness to the maturity structure of public debt

Next, we proceed by estimating the heterogeneity of the impact of the term structure of public debt on fiscal responsiveness across different maturity categories. Table 3 presents the estimation results for each maturity group, based on the dynamic model estimated using FE. Results obtained using alternative econometric methods are comparable and available upon request.

The coefficient associated with the interaction term for each respective debt maturity reflects the impact of public debt of that maturity on fiscal responsiveness, relative to the average responsiveness of primary balance to public debt. It should be interpreted as the effect of increasing the share

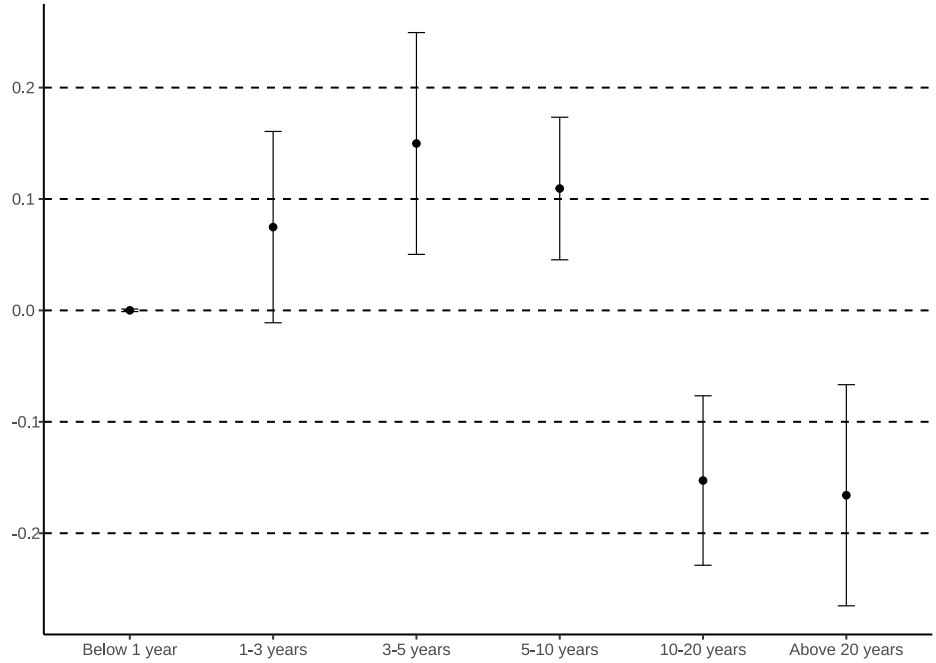
Table 3: Impact of the share of debt of specific maturity on fiscal responsiveness

Variable:	Below 1 year	1-3 years	3-5 years	5-10 years	10-20 years	Above 20 years
L.Primary balance	0.569***	0.566***	0.559***	0.587***	0.562***	0.558***
L.Debt	0.028***	0.017*	0.007	0.006	0.053***	0.053***
L.Debt#L.Share	0.0001	0.075*	0.150***	0.109***	-0.153***	-0.166***
Output Gap	0.571***	0.561***	0.582***	0.601***	0.582***	0.623***
Constant	-1.859*	-2.012*	-2.035**	-2.306**	-2.542**	-2.679***
R^2	0.539	0.542	0.548	0.559	0.562	0.564
Observations	506	506	506	506	506	506
Countries	19	19	19	19	19	19

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. Share stands for the share of public debt of a corresponding maturity group. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. Estimation is conducted using Fixed Effects (FE). *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

of public debt within a specific maturity range at the expense of other maturities. For instance, increasing the share of sovereign debt with a maturity of 1 to 3 years in the total stock at the expense of other maturities is associated with an improvement in the fiscal responsiveness coefficient by 0.0075. Conversely, increasing the share of debt with maturity exceeding 20 years reduces the fiscal responsiveness coefficient by 0.0166.

Figure 3: Impact of the share of debt of specific maturity on fiscal responsiveness



Note: Drawn by the authors using the estimation results reported in Table 3

In Figure 3, we plot the coefficients of the interaction terms for each respective maturity category

from Table 3 along with their confidence intervals. It is evident that sovereign debt with maturity between 1 and 10 years exerts a positive effect on fiscal responsiveness, with the strongest positive influence on the primary balance likely stemming from debt with maturity between 3 and 5 years. In contrast, sovereign debt with maturity exceeding 10 years does not enhance fiscal responsiveness. In fact, it has a significant negative impact, with larger stocks of long-term debt being associated with higher budget deficits or lower surpluses. The coefficients for debt with maturity above 10 years mean that indeed having a higher share of long-term debt significantly decreases fiscal responsiveness – the share of long-term debt being higher by 0.1 implies roughly 0.016 lower fiscal maturity. However, as explained above, this share has increased to only around 0.2 for a typical country in our sample. Thus, although fiscal responsiveness has decreased, it has likely stayed above zero, which corresponds to maintaining fiscal sustainability, albeit with more time required to stabilise the public debt-to-GDP ratio.

4.4 Weighted average maturity of public debt

Next, we adopt the weighted average maturity of public debt (WAM), measured in years, as an indicator of the extent to which the maturity structure is tilted toward longer-term debt. We use WAM to examine the impact of debt maturity on fiscal responsiveness, rather than focusing on the share of debt in each specific maturity group. Table 4 reports the estimation results. As anticipated and consistent with previous estimates, an increase in debt maturity reduces fiscal responsiveness.[7] According to the FE estimates from the dynamic model, if the maturity of sovereign obligations is by one year longer, fiscal responsiveness is lower by 0.0061. This implies that, if the effect is linear, the primary balance's response to public debt would be brought close to zero, i.e. fiscal policy would become unsustainable, if WAM reached 14 years.

In Appendix C, we perform a robustness analysis to check that the coefficients obtained here and above are not driven by any particular years or countries. In particular, we drop years of GFC and Covid-19 (see Table C.1) and five countries with the highest debt-to-GDP ratio (see Table C.2).

For illustrative purpose, we use the period from 2000 to 2020 to analyse for each country how a change in the WAM for each country has affected fiscal responsiveness. Based on the results presented in Table 4 and assuming that the fiscal responsiveness coefficient and the effect of increasing

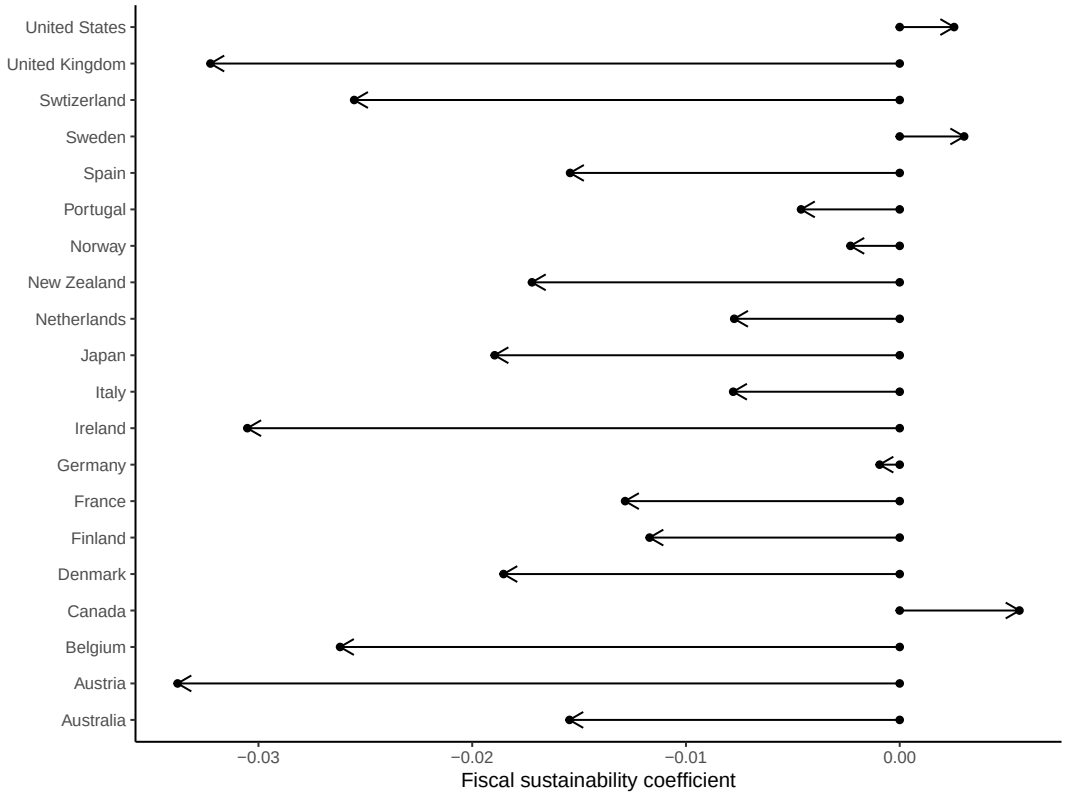
[7] It should be noted, that when interpreting and comparing the magnitude of estimated interaction coefficients one should bear in mind that the variable that stands for the share of debt is the proportion which varies between 0 and 1 while WAM is the number of years.

Table 4: Impact of the weighted average maturity of public debt on fiscal responsiveness

Variable	FE	FE lag	GMM-diff	GMM-sys	LSDVC
L.Primary balance	..	0.549***	0.267*	0.833***	0.590***
L.Debt	0.0933***	0.0847***	0.372***	0.144**	0.0819***
L.Debt#L.WAM	-0.00718***	-0.00612***	-0.0255***	-0.0192***	-0.00637***
Output gap	1.007***	0.611***	1.214***	0.389**	0.582***
Constant	-2.761***	-3.001***		-1.429	
R^2	0.379	0.582	..	..	..
Number of observations	468	468	448	468	468
Number of countries	19	19	19	19	19
Number of instruments	..	..	21	25	..
Hansen test	..	..	0.586	0.915	..
AR(1) test	..	..	0.287	0.133	..
AR(2) test	..	..	0.154	0.167	..

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. WAM stands for the weighted average maturity. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. The estimation is conducted using Fixed Effects (FE), one-step Difference GMM, one-step System GMM, and the bias-corrected Least Squares Dummy Variable (LSDVC) estimators. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

Figure 4: Contribution of the change in WAM of public debt in 2000-2020 to fiscal responsiveness



Source: Drawn by the authors using the estimation results reported in Table 4 and sovereign debt maturity structure. FE estimates of the dynamic panel regression are used.

WAM in each country are comparable to the sample average, we can estimate the contribution of WAM changes to the variation in fiscal responsiveness. Figure 4 presents these estimated changes in fiscal responsiveness attributable to shifts in WAM. The largest reduction in fiscal responsiveness resulting from the increase in the weighted average maturity of public debt is observed in the United kingdom, Ireland, Austria, Belgium and Switzerland. In contrast, the United States, Sweden and Canada experienced a decline in WAM, which has likely contributed to a slight improvement in fiscal responsiveness.

4.5 Role of interest rates

In the previous section, we have demonstrated that shifting from short-term to longer-term debt may reduce the government's incentive to respond to rising debt levels. When debt repayment or refinancing is a longer term perspective, particularly beyond the political cycle, it appears to become a lesser concern. However, this effect may not hold when interest rates increase, as higher rates would imply larger interest payments for the government. To assess whether the interest rate influences the relationship between fiscal responsiveness and debt maturity, we incorporate the interest rate as an additional variable in the analysis.[8]

We begin by incorporating the interest rate as an additional independent variable in the fiscal reaction function to explain the primary balance. Unlike WAM or the proportions of maturity groups, interest rates can influence the primary balance even in the absence of debt (see, for example, Tkačevs and Vilerts 2019). Therefore, we include the interest rate both as an interaction term with debt and as a standalone variable.

The estimation results are provided in Table 5 and indicate that the interest rate itself does not exert a statistically significant impact on the primary balance. On the one hand, higher interest rates increase the cost of public borrowing, thereby providing incentives for governments to reduce fiscal deficits to comply with fiscal rules. On the other hand, interest rates are typically raised in response to high inflation, prompting governments to support households and firms to mitigate the adverse effects of inflation, which can lead to deteriorating fiscal balances. Regarding the constraints imposed by fiscal rules, many countries have persistently violated them in the past and would, therefore, not react by improving primary balances as interest payments grow.

To explore whether the interest rate influences the interaction between debt maturity and fiscal

[8]The interest rate is calculated as the average rate on outstanding sovereign obligations by maturities weighted by their outstanding amounts.

Table 5: Impact of the interest rate on fiscal responsiveness

Variable	Primary balance	Primary balance
L.Primary balance		0.5510***
L.Debt	0.0317**	0.0267**
L.Debt#L.Intrate	0.0047	0.0068***
L.Intrate	0.1697	-0.0690
Output gap	0.9899***	0.6233***
Constant	-3.1146***	-2.7735***
R^2	0.3997	0.6016
Number of observations	467	467
Number of countries	19	19

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. Intrate stands for the weighted average interest rate. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. The estimation is conducted using Fixed Effects (FE) estimator. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

Table 6: Impact of debt maturity and interest rate on fiscal responsiveness

Variable	FE	FE lag	GMM-diff	GMM-sys	LSDVC
L.Primary balance	..	0.558***	0.464***	0.710***	0.600***
L.Debt	0.0744***	0.0643***	0.0884***	0.0538*	0.0607***
L.Debt#L.WAM	-0.00423**	-0.00418***	-0.00565***	-0.00831***	-0.00430***
L.Debt#L.WAM#L.Intrate	5.10e-05	0.000797**	0.000837**	0.00192***	0.000814**
L.Intrate	0.352***	-0.00328	-0.0309	-0.407*	-0.0150
Outputgap	0.973***	0.619***	0.767***	0.648***	0.593***
Constant	-3.946***	-3.358***		-0.791	
R^2	0.406	0.607	..	..	..
Number of observations	467	467	446	467	467
Number of countries	19	19	19	19	19
No of instruments	..	..	329	29	..
Hansen test	..	..	1.000	0.837	..
AR(1) test	..	..	0.184	0.121	..
AR(2) test	..	..	0.755	0.678	..

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. WAM stands for the weighted average maturity. Intrate stands for the weighted average interest rate. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. Estimation is conducted using Fixed Effects (FE), one-step Difference GMM, one-step System GMM, and the bias-corrected Least Squares Dummy Variable (LSDVC) estimators. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

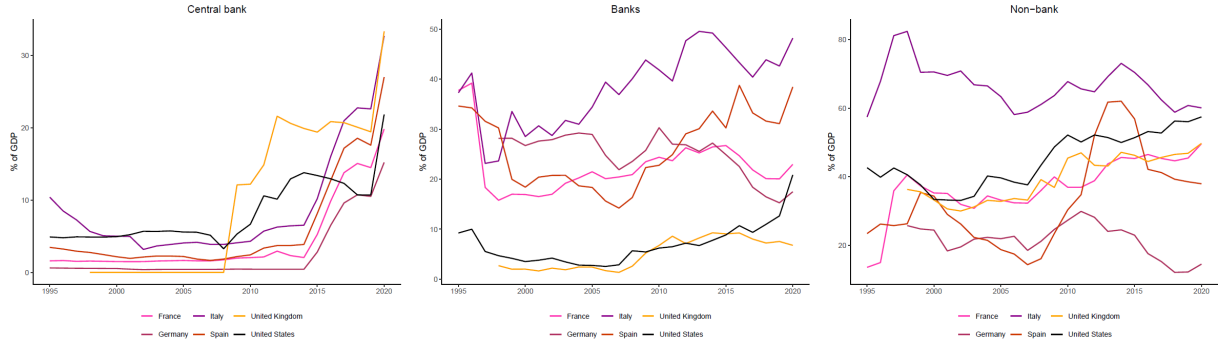
responsiveness, we introduce an interaction term between the interest rate with the weighted average maturity of public debt. The results presented in Table 6 indicate that higher interest rates mitigate the negative effect that increased debt maturity has on fiscal response coefficients. Again, using the FE estimates from the dynamic model as a benchmark and assuming a zero interest rate,

an extension of WAM to 15 years eliminates the primary balance's responsiveness to public debt. However, as the interest rate increases, WAM would need to rise to an implausible level to achieve a fiscal response of zero. The required WAM increases are smaller when using the coefficients estimated using the GMM-system method.

4.6 Debt holders

We next explore potential explanations for the observed relationship between sovereign debt maturity and fiscal responsiveness. One possible explanation may lie in the change in the ownership structure of sovereign debt. Figure 5 presents the distribution of sovereign debt holdings of selected countries across three categories of agents: banks, non-bank institutions and the central bank of the respective country (the ECB for the Euro Area).[9]

Figure 5: Holders of sovereign debt for selected countries



Source: Arslanalp and Tsuda (2014)

The proportion of central bank holdings of sovereign debt has increased rapidly from very low levels prior to the Great Recession. In contrast, commercial banks holdings have generally been on a gradual upward trend, while non-bank holdings fluctuated without a clear pattern. Importantly, a visual inspection of Figure 5 suggests that the sovereign debt holdings of different agent groups are uncorrelated. This lack of correlation allows for their use as independent variables in a single regression model, enabling the simultaneous estimation of fiscal responsiveness for each segment of government debt:

$$PB_{i,t} = \beta_0 + \beta_{1,k} D_{i,k,t-1} + \beta_3 Y_{i,t} + \gamma_i + \varepsilon_{i,t} \tag{3}$$

[9]It is important to note that the values represented by the lines for each country across the three graphs sum up to this country's debt-to-GDP ratio rather than to 100%.

where $PB_{i,t}$ is the primary balance-to-GDP ratio in year t and country i, $D_{i,k,t-1}$ is the public debt-to-GDP ratio held by one of four agent groups (foreign officials, commercial banks, non-bank institutions, domestic central bank), $Y_{i,t}$ is the output gap to account for the cyclical component of the primary balance, γ_i is the unobserved country fixed effect, and $\varepsilon_{i,t}$ is a standard i.i.d. disturbance term.

Table 7: Fiscal responsiveness to sovereign debt stock by groups of holders

Variable	FE	FE lag	GMM-diff	GMM-sys	LSDVC
L.Primary balance		0.566***	0.539***	0.684***	0.618***
L.Foreign official	0.0422	0.0465*	0.0458	0.0118	0.0459**
L.Bank	0.0712***	0.102***	0.0934***	0.131***	0.0977***
L.Non-bank	0.0403	0.0560**	0.0647***	0.0501	0.0544***
L.Domestic CB	0.0293	0.000755	0.00230	-0.107***	-0.0127
Output gap	1.082***	0.709***	0.737***	0.819***	0.681***
Constant	-3.059**	-4.381***		-3.829**	
R^2	0.396	0.584	..	..	..
Number of observations	400	399	380	399	399
Number of countries	19	19	19	19	19
Number of instruments	..	..	364	25	..
Hansen test	..	..	1.000	0.774	..
AR(1) test	..	..	0.177	0.193	..
AR(2) test	..	..	0.602	0.533	..

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. The estimation is conducted using Fixed Effects (FE), one-step Difference GMM, one-step System GMM, and the bias-corrected Least Squares Dummy Variable (LSDVC) estimators. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

The estimation results (presented in Table 7) indicate that sovereign debt holdings by the domestic central bank do not contribute to an improvement in the primary balance. Across all econometric specifications, no positive and statistically significant coefficient is found for central bank-held debt. In fact, in the case of the GMM system estimation, the coefficient is even negative and statistically significant. In contrast, debt held by other entities exerts a positive influence on the primary balance, with the effect of bank-held debt consistently positive and significant.

These findings suggest a potential hypothesis: actions of central banks may have contributed to the observed increase in the average maturity of public debt and the corresponding decline in fiscal responsiveness. In the next section, we interpret and contextualise the obtained results, providing further analysis to explore this hypothesis.

4.7 Role of unconventional monetary policy

Unfortunately, data on holders of sovereign debt by Arslanalp and Tsuda (2014) do not contain any information on debt maturity. However, we can study the impact of central bank actions using other tools.

It is important to remember the difference between conventional and unconventional monetary policy. The former affects only the short-term interest rate and thus cannot have a direct effect on the maturity structure of public debt. Conversely, the latter includes asset purchases and other unconventional measures, and is precisely aimed at lowering interest rates at the further end of the yield curve. This is required to make long-term borrowing cheaper, resulting in more economic stimulus when short-term rates are stuck at an effective lower bound. Thereby, when central banks implement unconventional monetary policy and accumulate government debt on their balance sheets, the flattening yield curve creates an incentive for fiscal authorities to move to debt with longer maturities.

As can be gauged from Figure 5, in the majority of countries central banks started large-scale asset purchases in only 2015.[10] In two major countries, the United States and the United Kingdom, this happened earlier, in 2008 and 2009 respectively. Hence we can verify if the relationship between debt maturity and fiscal responsiveness holds even before the start of the large-scale quantitative easing.

We re-estimate the fiscal reaction function with the interaction with a share of long-term debt and WAM for the period prior to the QE and present the estimation results in Table 8. The magnitude of the interaction term coefficients is only slightly lower than previously and remains statistically significant. The economic interpretation of the coefficients also remains unchanged: it takes the share of long-term debt to reach around 50% to undo the positive effect of public debt on primary balance. This clearly shows that the established relationship between fiscal responsiveness and debt maturity existed before the start of government debt purchases by central banks. At the same time, it might still be the case that the central banks' actions intensified this effect.

To test this, we turn to a key variable affected by quantitative easing: the slope of the yield curve. Central banks' commitment to lowering interest rates for longer maturities through unconventional monetary policy has resulted in a flattening of the yield curve. Using the dataset from De Graeve

[10] Some QE programmes took place even before that, but they are dwarfed by the scale of government-issued asset purchases after 2015.

Table 8: Impact of public debt maturity on fiscal responsiveness before QE

Variable	(1)	(2)
L.Primary balance	0.5553***	0.5771***
L.Debt	0.0739***	0.0779***
L.Debt#L.Longshare	-0.1269***	
L.Debt#L.WAM		-0.0046***
Output gap	0.5233***	0.4996***
Constant	-2.9284**	-3.0386**
R^2	0.6200	0.6099
Number of observations	354	354
Number of countries	19	19

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. Longshare stands for the share of long-term debt (10y and above), WAM is the weighted-average maturity. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. The estimation is conducted using Fixed Effects (FE) estimator. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

and Mazzolini (2023), we obtain information on the effective interest rates applicable to government debt across different maturities. This dataset thus provides a direct measure of how central banks' interest rate management across the full maturity spectrum has influenced the cost of public debt. We define the slope of the yield curve as the difference between the average interest rate on debt with maturities of 9 to 10 years and that on debt with maturities of 1 to 2 years. As we show in Figure B.2, on average across the developed countries, the yield curves were flattening during 2010s, and the average difference between the interest rates on sovereign debt of long and short maturities reached an all-time low in 2019. We add the interaction with the slope of the yield curve as an additional control variable into the fiscal reaction function:

$$PB_{i,t} = \beta_0 + \beta_1 D_{i,t-1} + \beta_2 D_{i,t-1} * I_{i,t-1} + \beta_3 D_{i,t-1} * S_{i,t-1} + \beta_4 Y_{i,t} + \gamma_i + \varepsilon_{i,t} \tag{4}$$

where $PB_{i,t}$ is the primary balance-to-GDP ratio in year t and country i, $D_{i,t-1}$ is the public debt-to-GDP ratio lagged by one year, $I_{i,t-1}$ is an interaction variable which is either the share of long-term debt or the weighted average maturity, $S_{i,t-1}$ is an interaction variable which is the slope of the yield curve, $Y_{i,t}$ is the output gap to account for the cyclical component of the primary balance, γ_i is the unobserved country fixed effect and $\varepsilon_{i,t}$ is a standard i.i.d. disturbance term.

Table 9 presents the estimation results. Two significant findings emerge. First, the coefficient for the interaction between the public debt ratio and the slope of the yield curve is positive and

Table 9: Impact of public debt maturity on fiscal responsiveness accounting for the slope of the yield curve

Variable	(1)	(2)
L.Primary balance	0.5651***	0.5774***
L.Debt	0.0684***	0.0791***
L.Debt#L.Longshare	-0.1298***	
L.Debt#L.WAM		-0.0058***
L.Debt#L.Slope	0.0054**	0.0053**
Output gap	0.6305***	0.6421***
Constant	-2.9802***	-3.0927***
R^2	0.5986	0.5936
Number of observations	468	468
Number of countries	19	19

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. Longshare stands for the share of long-term debt (10y and above), WAM is the weighted-average maturity. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. The estimation is conducted using Fixed Effects (FE) estimator. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

statistically significant at the 95% confidence level. This indicates that a steeper yield curve enhances fiscal responsiveness. In other words, fiscal authorities become more responsive to rising public debt ratios, improving the budget balance more substantially when long-term interest rates are significantly higher than short-term rates.

Second, the coefficients for the interaction terms between public debt as well as both the share of long-term debt and the weighted maturity of debt remain virtually unchanged after the inclusion of the yield curve slope as an additional control variable in the fiscal reaction function. This suggests that the effect of debt maturity on fiscal responsiveness is not solely driven by the yield curve slope. If this were the case, the coefficients related to debt maturity would lose significance upon the introduction of the slope as an independent factor into the regression. Therefore, it can be inferred that the observed tendency of governments to reduce fiscal responsiveness while extending the maturity of their debt obligations is not solely attributable to unconventional monetary policy or central banks' efforts to lower long-term interest rates, including quantitative easing.

The organization of the regression above relies on a critical assumption: the independence of debt maturity (or the share of long-term debt) from the slope of the yield curve. However, it is highly likely that a reduction in the difference between long- and short-term interest rates incentivizes fiscal authorities to shift towards issuing longer-term obligations.

To account for the potential increase in debt maturity due to the change of the yield curve slope, we employ IV estimation. We instrument debt maturity (either the share of the long-term debt or WAM) using the yield curve slope and include the instrumented debt maturity variable in the fiscal reaction function:

$$PB_{i,t} = \beta_0 + \beta_1 D_{i,t-1} + \beta_2 D_{i,t-1} * I^{instr}_{i,t-1} + \beta_3 Y_{i,t} + \gamma_i + \varepsilon_{i,t} \tag{5}$$

where $PB_{i,t}$ is the primary balance-to-GDP ratio in year t and country i, $D_{i,t-1}$ is the public debt-to-GDP ratio lagged by one year, $I_{i,t-1}$ is an interaction variable which is either the share of long-term debt or the weighted average maturity, $Y_{i,t}$ is the output gap to account for the cyclical component of the primary balance, γ_i is unobserved country fixed effect and $\varepsilon_{i,t}$ is a standard i.i.d. disturbance term. The interaction variable is instrumented with the slope of the yield curve.

Table 10: Impact of public debt maturity instrumented by the slope of the yield curve on fiscal responsiveness

Variable	(1)	(2)
L.Debt	0.1542***	0.1875***
L.Debt#L.Longshare Instrumented	-0.3992***	
L.Debt#L.WAM Instrumented		-0.0178***
Outputgap	1.0465***	1.0547***
R^2	0.2846	0.2750
Number of observations	468	468
Number of countries	19	19
Instruments	10Y.yield – 1Y.yield	10Y.yield – 1Y.yield
Hansen J-stat	0.244	0.014
SW Chi-sq stat	87.33***	137.37***
SW F-stat	43.28***	68.07***

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. Longshare stands for the share of long-term debt (10y and above), WAM is the weighted-average maturity. Hansen J-stat is a test of instrument validity (i.e. that they are not correlated with the error term of the main equation). The failure to reject the null hypothesis implies that instruments are valid. The Sanderson-Windmeijer (SW) first-stage chi-squared and F statistics are tests of instrument relevance. The null of the SW Chi-sq test is that the instrumented variable is unidentified, the null of the SW Chi F test is that the instrumented variable is weakly identified. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. Estimation is conducted using IV estimator. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

The IV estimation results are documented in Table 10. It appears that public debt maturity measures, instrumented by the slope of the yield curve, exhibit a negative and statistically significant effect on fiscal responsiveness. This implies that unconventional monetary policy, aimed at lowering long-term yields, incentivised fiscal authorities to extend public debt maturity, which in turn had a

negative effect on fiscal responsiveness.

However, a question arises as to whether does the yield curve slope fully account for the negative relationship between debt maturity and fiscal responsiveness. If this were the case, the portion of maturity variation unrelated to the yield curve slope should have no significant effect on fiscal responsiveness. To test this hypothesis, we interact sovereign debt with maturity measures that have been purged of their relationship with the yield curve slope. Specifically, we first regress the measures of sovereign debt maturity ($I_{i,t}$) on the yield curve slope ($S_{i,t}$) and obtain the residuals ($\xi_{i,t}$):

$$I_{i,t} = \alpha_0 + \alpha_1 S_{i,t} + \nu_i + \xi_{i,t} \tag{6}$$

Next, we include interactions of sovereign debt with the residual series in the fiscal reaction function:

$$PB_{i,t} = \beta_0 + \beta_1 D_{i,t-1} + \beta_2 D_{i,t-1} * \xi_{i,t-1} + \beta_3 Y_{i,t} + \gamma_i + \varepsilon_{i,t} \tag{7}$$

Table 11: Impact of public debt maturity related to other factors than the yield curve slope on fiscal responsiveness

Variable	(1)	(2)
L.Primary balance	0.5917***	0.5857***
L.Debt	0.1511***	0.1321***
L.Debt#L.Longshare unexplained	-0.3809***	
L.Debt#L.WAM unexplained		-0.0102***
Output gap	0.6602***	0.6462***
Constant	-4.3372***	-4.1908***
R^2	0.5737	0.5686
Number of observations	467	467
Number of countries	19	19

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. "Longshare unexplained" stands for the part of the share of long-term debt (10y and above) which is not explained by the slope of the yield curve. "WAM unexplained" is the part of the weighted-average maturity which is not explained by the slope of the yield curve. The sample comprises annual panel data for 19 developed countries over the period 1995–2020. The estimation is conducted using Fixed Effects (FE) estimator. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

Table 11 presents the results. The findings indicate that the component of sovereign debt maturity unrelated to the yield curve slope and other covariates has a statistically significant negative impact on fiscal responsiveness. This suggests that factors affecting debt maturity unrelated to the

yield curve slope contribute to the reduction in fiscal responsiveness due to a longer debt maturity. Identifying these additional factors, however, falls beyond the scope of this study and is left for future research.

5 Conclusion

Amid rising sovereign debt and increasing debt maturities, this study investigates the role of the term structure of public debt for fiscal sustainability. It measures fiscal sustainability using the fiscal responsiveness coefficient that relates primary balance to lagged public debt in the fiscal reaction function. This approach, introduced by Bohn (1998), is still the most popular backward-looking way to evaluate fiscal sustainability. For the sample of advanced economies over the period from 1995 to 2020 our paper estimates fiscal responsiveness of around 0.03, meaning that the rise in public debt-to-GDP ratio by 10 percentage points leads to fiscal tightening of around 0.3 percentage points of GDP.

The results of this study indicate that a shift in the term structure of public debt towards longer maturity of sovereign obligations negatively affects fiscal responsiveness. Fiscal responsiveness is the highest to public debt with maturity between 3 and 5 years, which roughly aligns with the electoral cycle in many countries, while for public debt due in more than 10 years it is even negative. Specifically, the findings show that each percentage point of the share of debt with maturity exceeding 10 years is associated with reduced fiscal responsiveness by 0.0014. This implies that for the average developed country, the increase of the share of long-term debt to around 20% over the last decades can be linked to the decrease in fiscal responsiveness by half. However, it would take this share to reach almost 0.5 to reduce fiscal responsiveness to zero, which would correspond to an unsustainable fiscal policy. Similarly, the response of primary balance to public debt would become negligible if the weighted average maturity of public debt reached approximately 14 years. For a typical country in our sample, this measure climbed from 5 to 8 years during the first two decades of this century, which also corresponds to fiscal responsiveness reduced approximately by half. We interpret these results as follows: by extending debt repayment into the more distant future, fiscal authorities may become complacent, feeling less urgency to convince markets in the sustainability of fiscal policy and persuading them to allow for a longer adjustment of the public debt ratio. This interpretation is further supported by our finding that the negative effect of longer maturities is mitigated when

interest rates rise, as governments face increasing pressure from higher interest payments.

The shift to longer maturities of public debt has been profound, especially when central banks started to implement unconventional monetary policy, thus lowering long-term interest rates, which incentivise sovereign borrowing of longer maturity, associated with weaker fiscal responsiveness. Our findings highlight the importance of the yield curve slope in explaining both the shift toward longer maturity of public debt and the accompanying negative impact on fiscal responsiveness. At the same time, we provide evidence that longer debt maturities have a negative effect on fiscal responsiveness even when they are not directly linked to monetary policy interventions aimed at flattening the yield curve. Indeed, this negative effect on fiscal responsiveness was present even before the adoption of ultra-loose monetary policies. While expansionary monetary policy over the last decade has exacerbated this effect, it is not the sole factor through which longer debt maturities undermine fiscal sustainability. Future research should investigate these other contributing factors.

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Appendix

A Data: variables and sources

Table A.1: List of variables used in the study, their definition and source

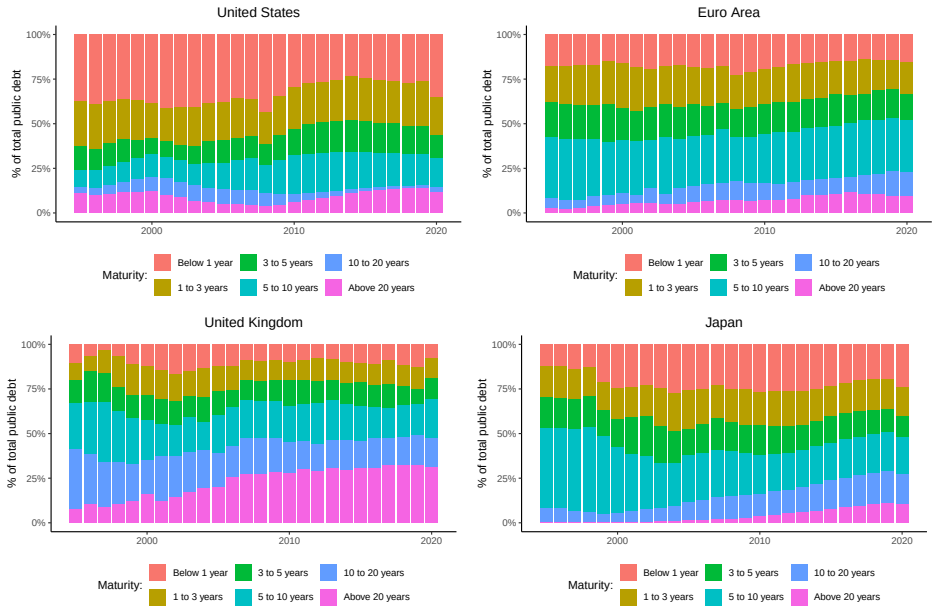
Variable	Data source	Definition
Primary balance	IMF WEO October 23	General government net borrowing, excluding interest payable, % of GDP
Output gap	IMF WEO October 23	Gap between actual and potential GDP, % of potential GDP
GDP	IMF WEO October 23	Local currency
Public debt	IMF WEO October 23	General government consolidated gross debt, % of GDP
Public debt by narrow groups by residual maturity (from less than 3 months to more than 30 years)	De Graeve and Mazzolini (2023)	Face value, local currency
Weighted average maturity of outstanding debt	De Graeve and Mazzolini (2023)	Years
Yield curves estimates (1y - 30y)	De Graeve and Mazzolini (2023)	%
Debt held by domestic CB	Arslanalp and Tsuda (2014)	Face value, local currency
Debt held by domestic banks	Arslanalp and Tsuda (2014)	Face value, local currency
Debt held by domestic non-banks	Arslanalp and Tsuda (2014)	Face value, local currency
Debt held by foreign official sector	Arslanalp and Tsuda (2014)	Face value, local currency
Debt held by foreign banks	Arslanalp and Tsuda (2014)	Face value, local currency
Debt held by foreign non-banks	Arslanalp and Tsuda (2014)	Face value, local currency

B Summary statistics

Table B.1: Summary statistics

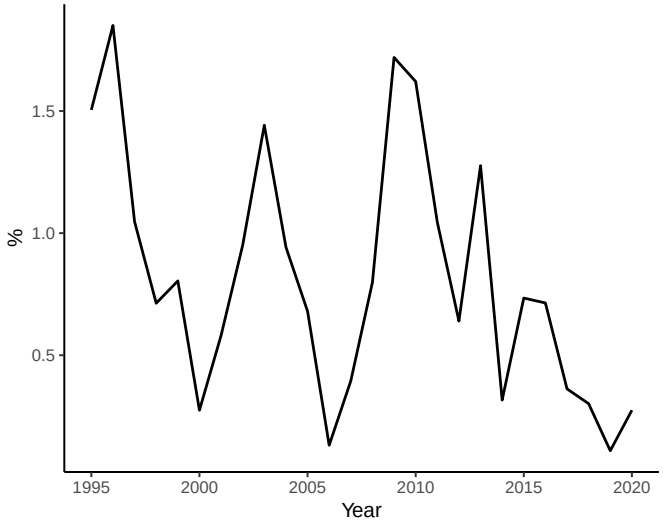
Variable	N	min	max	median	mean	std
Total debt, % of GDP	554	9.671	258.612	63.348	72.099	41.175
Sum debt, % of GDP	560	4.588	211.404	41.636	50.404	33.815
Debt below 10y, % of GDP	560	3.4	143.633	33.715	38.919	25.678
Debt above 10y, % of GDP	560	0	68.962	8.291	11.485	10.234
Debt below 1y, % of GDP	560	0.07	50.667	7.691	9.932	8.251
Debt between 1y and 5y, % of GDP	560	1.478	62.738	15.615	17.886	11.889
Debt between 5y and 10y, % of GDP	560	0.941	35.946	9.492	11.101	7.248
Share of debt at least 10y, %	560	0	0.534	0.207	0.221	0.099
WAM, years	560	2.146	14.848	6.18	6.483	2.144
Foreign official, % of GDP	560	0	29.469	0.528	2.338	4.038
Bank, % of GDP	452	0.732	102.132	16.486	20.268	16.267
Non-Bank, % of GDP	446	5.302	82.412	32.673	34.079	16.654
Domestic CB, % of GDP	493	0	97.149	1.594	5.32	10.581
Interest rate, %	557	-1.906	11.988	3.017	2.923	1.981
Long-term interest rate, %	520	-0.516	12.229	3.787	3.499	2.183

Figure B.1: Dynamics of the maturity structure of public debt in selected advanced countries



Data source: De Graeve and Mazzolini (2023)

Figure B.2: Average slope of the yield curve of public debt across developed countries



The chart depicts the difference between the average interest rate payable on sovereign debt of maturity between 9 and 10 years and of maturity between 1 and 2 years, average across the 19 countries in our sample.
Data source: De Graeve and Mazzolini (2023)

C Robustness analysis

Table C.1: Impact of public debt maturity on fiscal responsiveness excluding crisis years: 2009, 2010, and 2020

Variable	(1)	(2)
L.Primary balance	0.5598***	0.5621***
L.Debt	0.0450***	0.0528***
L.Debt#L.Longshare	-0.0739***	
L.Debt#L.WAM		-0.0035***
Outputgap	0.2852***	0.2824***
Constant	-1.4934**	-1.5705**
R^2	0.6391	0.6393
Number of observations	449	449
Number of countries	19	19

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. Longshare stands for the share of long-term debt (10y and above), WAM is the weighted-average maturity. The sample comprises annual panel data for 19 developed countries over the period 1995-2008 and 2011–2019. Years 2009, 2010 and 2020 are excluded from the estimation. The estimation is conducted using Fixed Effects (FE) estimator. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.

Table C.2: Impact of public debt maturity on fiscal responsiveness excluding the five countries with the highest public debt ratio

Variable	(1)	(2)
L.Primary balance	0.5210***	0.5421***
L.Debt	0.1024***	0.1085***
L.Debt#L.Longshare	-0.1878***	
L.Debt#L.WAM		-0.0065***
Outputgap	0.7419***	0.7374***
Constant	-2.8940**	-3.1791**
R^2	0.5916	0.5816
Number of observations	378	378
Number of countries	14	14

Notes: The dependent variable is the primary balance expressed as a percentage of GDP. Longshare stands for the share of long-term debt (10y and above), WAM is the weighted-average maturity. The sample comprises of annual panel data for 14 developed countries over the period 1995–2020: countries with the highest debt-to-GDP ratio, namely Belgium, Italy, Japan, Portugal, and the United States, are excluded from this estimation. The estimation is conducted using Fixed Effects (FE) estimator. *, **, and *** denote significance at the level of 0.1, 0.05, and 0.01 respectively.