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Abstract

Recent theoretical studies have highlighted that both the level of public debt and the unit cost of servicing the debt (r-g) play a role in the sustainability of public finances. This paper builds on this literature and introduces a new approach to analysing the relationship between economic downturns and sovereign debt risks by considering the total public debt burden, that is, the interaction between the level of debt and r-g. We conduct this analysis for 18 advanced economies over a span of 150 years, uncovering three novel findings. First, we document that the level of public debt and the interest-growth differential convey distinct information about public finances conditions, reinforcing the argument for incorporating both measures in the assessment of sovereign debt sustainability risks. Second, we offer a long-term historical perspective on the role of the total public debt burden in shaping the severity of recessions and the pace of subsequent recoveries. Our findings demonstrate that a high public debt burden is associated with deeper economic contractions, sharper declines in investment, deflationary pressures and pronounced credit contractions during recessions. Further analysis of plausible transmission mechanisms suggests that an elevated total debt burden at the onset of recessions is linked to more limited accommodative policies during financial crises. Third, we document the feedback effects of financial crises on the components of the total public debt burden, demonstrating that both the level and cost of public debt systematically deteriorate, thereby heightening the risk of sovereign debt crises in the aftermath of financial turmoil.

Keywords: financial crises, sovereign debt sustainability, r-g, local projections.

JEL classification: E62, G01, H63.

Resumen

Estudios teóricos recientes han destacado que tanto el nivel de deuda pública como el coste unitario de servicio de la deuda (r-g) juegan un papel en la sostenibilidad de las finanzas públicas. Este artículo introduce un nuevo enfoque para analizar la relación entre las recesiones económicas y los riesgos de deuda soberana al considerar el coste total de la deuda pública, es decir, la interacción entre el nivel de deuda y r-g. Realizamos este análisis para 18 economías avanzadas durante un período de 150 años, y obtenemos tres resultados novedosos. Primero, documentamos que el nivel de deuda pública y el diferencial de crecimiento de intereses capturan información distinta sobre las condiciones de las finanzas públicas, lo que refuerza el argumento de incorporar ambas medidas en la evaluación de los riesgos de sostenibilidad de la deuda soberana en estudios empíricos. Segundo, ofrecemos una perspectiva histórica a largo plazo sobre el papel del coste total de la deuda pública en la configuración de la severidad de las recesiones y el ritmo de las recuperaciones posteriores. Obtenemos que una alta carga de deuda pública al comienzo de una crisis está asociada con recesiones económicas más profundas, caídas más pronunciadas en la inversión, presiones deflacionarias y contracciones crediticias. Un análisis adicional de los mecanismos de transmisión plausibles sugiere que un coste total de deuda elevada al inicio de las recesiones está asociado a políticas acomodaticias más limitadas durante las crisis financieras. Tercero, documentamos los efectos de retroalimentación de las crisis financieras sobre los componentes del coste total de la deuda pública, demostrando que tanto el nivel como el coste de la deuda pública se deterioran sistemáticamente, lo que aumenta el riesgo de crisis de deuda soberana después de una crisis financiera.

Palabras clave: crisis financieras, sostenibilidad de la deuda soberana, r-g, proyecciones locales.

Códigos JEL: E62, G01, H63.

1 Introduction

The impact of public finances on the economy, particularly concerning periods of economic decline such as recessions and their subsequent recoveries, remains a topic of ongoing debate among economists. The lack of consensus partly stems from the complex dynamics underlying the relationship between sovereign debt, its sustainability, and economic outcomes across countries. Traditionally, empirical analysis of the sustainability of sovereign debt and its impact on the economy has used the *stock approach* as a proxy for the stability of public finances (Reinhart and Rogoff, 2009; Jordà *et al.*, 2016; Romer and Romer, 2018, 2019). However, recent theoretical research has argued that not only public debt but also the unit cost of servicing the debt, defined as the difference between the interest rate and the output growth rate, $r - g$, is a crucial factor to determine public debt sustainability (Barrett, 2018; Blanchard, 2019; Mehrotra and Sergeyev, 2021; Mian *et al.*, 2022).[1] This strand of the literature highlights the importance of incorporating $r - g$ as an additional factor in assessing whether a given level of public debt can be considered sustainable or, conversely, poses a potential risk to the stability of public finances. The role of $r - g$ can be illustrated by Blanchard (2019)'s remark that "*put bluntly, public debt may have no fiscal cost*" if the interest-growth differential is on average negative over time. The relevance of $r - g$ is also emphasized in Boone *et al.* (2022)'s recent report on global debt, where they report that declining and relatively low debt servicing costs over the last two decades have reduced sustainability risks despite countries experiencing very high levels of sovereign debt.

In this paper, we build on these insights to conduct a historical analysis of the relationship between financial and nonfinancial crises and sovereign debt sustainability, incorporating both the level of public debt and $r - g$. The inclusion of $r - g$ as a measure of public finance vulnerabilities is further motivated by a newly documented historical stylized fact presented in this study. We show that, for the quasi-universe of advanced economies spanning the last 150 years, there have been recurring historical episodes where both a high (low) debt-to-GDP ratio and a low (high) or even negative unit cost of servicing the debt have simultaneously co-existed. This empirical evidence highlights that the total debt burden, defined as the interaction between the level of public debt and $r - g$, conveys information that is distinct from that embedded solely in the level of public debt.[2] In addition, we investigate whether there is a systematic or

[1] The use of the term *stock approach* is due to Mehrotra and Sergeyev (2021). They label as *stock approach* those studies that focus on the level of the public debt-to-GDP ratio or its distribution. The *flow approach*, in turn, refers to those studies that focus on the trajectory of the debt-to-GDP ratio and considers that $r - g$ plays a major role in the dynamics of public debt level.

[2] We use the terms total debt burden, total debt cost and total cost of servicing public debt interchangeably

predictable pattern between the level and cost of public debt and financial crises. We show that financial crises are not preceded by periods of either high public debt level, $r - g$ or total debt burden. Therefore, these results, together with previous ones in the literature about public debt levels, point to neither public debt nor $r-g$ as leading indicators of financial crises. This finding does not support arguments whereby episodes of high public debt and $r - g$ systematically lead to periods of financial instability such as financial crises.

Building on the novel evidence highlighted above, we examine the link between the total debt burden and the extent of the impact of financial and nonfinancial crises. In particular, we examine whether key macroeconomic variables such as as output, investment, prices, and credit, have a differentiated path in the recession and recovery phase depending on the total public debt burden prior to the crises. We find that when the initial total cost of servicing the debt is historically high, the effects of a financial crisis are characterized by larger output and investment losses, sluggish recoveries, credit crunches and deflationary pressures. For the case of nonfinancial economic crises, the results are similar although quantitatively less pronounced. Our findings align with arguments in the literature emphasizing the precautionary rationale for maintaining sound public finances, enabling governments to credibly commit to economic stabilization during periods of crises. We conjecture that the government's limited fiscal space in the aftermath of economic and financial downturns may account for these findings. To investigate this conjecture, we estimate the conditional paths of cyclically-adjusted government expenditure and revenue along with both short- and long-term interest rates. The results indicate that, particularly during financial crises, accommodative policies are less supportive when public debt conditions are more adverse at the peak of the business cycle.

We finalise our empirical analysis by examining the extent to which economic recessions influence the sustainability of the public finances through their effect on the components of the total debt burden. We find that financial crises are not only followed by periods of high public debt, as already documented in the literature (e.g. Reinhart and Rogoff, 2009), but also by increases in $r - g$. This result suggests that sovereign debt sustainability is clearly threatened in the aftermath of, in particular, financial crises, as simultaneous increases in public debt and $r-g$ can originate feedback loops between sovereign debt and the cost of it (see e.g. Engen and Hubbard, 2004; Laubach, 2009). This empirical finding highlights the essential role of financial

throughout the paper. This terminology is consistent with that used in Mehrotra and Sergeyev (2021). We note that the interaction between the level of public debt and $r - g$ has also been referred to as effective interest payment (e.g. Ostry *et al.*, 2010).

stability in preventing future episodes of public debt instability.

Related Literature. Our paper relates to two strands of the economic literature. First, our work builds on theoretical studies that have shown that both the level of public debt and the cost of servicing the debt $(r - g)$ play a role in the sustainability of public finances. The secular stagnation advanced economies have been experiencing since the Great Financial Crisis (GFC) has introduced a new ingredient in the analysis of public debt dynamics, a persistently low r and $r < g$. This has generated a constructive discussion about the possibility of a "free lunch" in sovereign debt, i.e., increases in debt without later increases in primary surpluses. This issue was notably raised by Blanchard (2019, 2023). He alerted that fiscal costs of public debt issuance might not be as high as usually assumed, and that debt rollovers are feasible within a context of $r < g$. Mian *et al.* (2022) argue that the free lunch condition is tighter as it also includes the sensitivity of $r - g$ to the level of debt. In their analysis of fiscal space at or near the zero lower bound (ZLB) they obtain a non-monotone relationship between debt and deficits with the possibility that greater deficits may reduce debt. Another set of papers argue that government debt enjoys a convenience yield (or debt revenue channel) that keeps r low(er) facilitating the sustainability of debt (Berentsen and Waller, 2018; Brunnermeier *et al.*, 2022; Reis, 2022). This premium reflects future service flows related to safety, liquidity and regulatory considerations. Although low r and $r < g$ keep in principle public debt (more) manageable, theoretical studies have also accounted for the fact that the interest rate r may not only reflect fundamentals but also non-fundamental factors that introduce rollover risks and multiple equilibria. In this regard, it has also been shown that low enough levels of sovereign debt (Blanchard *et al.*, 2021; Blanchard, 2023) or debt servicing cost (Corsetti and Dedola, 2016; Lorenzoni and Werning, 2019) can avoid the so-called "bad equilibria".

Our empirical approach builds on this theoretical literature by considering both the level of sovereign debt and $r - g$ to analyse the role of the total public debt burden—defined as the interaction of these two terms—on economic recessions. In our analysis, we are careful to ensure the empirical measure of $r - g$ approximates its theoretical counterpart as closely as possible. Furthermore, we document that $r < g$ is historically a relevant empirical configuration for the quasi-universe of advanced economies.

Regarding the second strand of the literature this paper relates to, we contribute to a range of work assessing the empirical relationship between financial crises and sovereign debt sustainability risks (Reinhart and Rogoff, 2009, 2011; Jordà *et al.*, 2016; Romer and Romer, 2018, 2019). To the best of our knowledge, there are only a few studies that empirically explore the dynamic interlink between public debt sustainability risks and financial crises using long-term historical data. Reinhart and Rogoff (2009) use a range of banking crisis episodes in both developed and emerging economies after World War I to show that financial crises have a long-lasting impact on public debt. They show that governments typically experience a substantial increase in their debt-to-GDP ratios in the aftermath of a crisis, and that the elevated debt levels persist for an extended period. We complement their work by showing that the aftermath of financial crises are not only followed by sizeable increases in public debt, but also in the unit cost of servicing the debt $r-g$. Our empirical finding is consistent with Reinhart and Rogoff (2011), who finds, using data from both advanced and emerging economies, that banking crises are significant predictors of sovereign debt crises, rather than the other way around.

The empirical evidence on the relationship between fiscal space–proxied by public debt levels– at the onset of a financial crisis and the subsequent severity of the crisis is, on the other hand, mixed. Using an older version of the JST Macrohistory Database that we use in this paper, Jordà *et al.* (2016) empirically address this question and find limited evidence that initial high levels of public debt, taken in isolation, systematically lead to significantly deeper and larger financial recessions.[3] They also find that financial crises are not predicted by public debt build-ups. On the other hand, Romer and Romer (2018) find a positive association between a low debt-to-GDP ratio at the onset of the crisis and a milder financial recession. They suggest that a higher fiscal space generated by a lower debt-to-GDP when the crisis hits can explain their result. In a follow-up work, Romer and Romer (2019) explore this mechanism in more detail and show that the fiscal response following a financial crisis can be explained by a combination of both market access problems (e.g., an increase in sovereign yield levels) and the choices of international organizations or policymakers (e.g., turn to austerity when public debt is high but not otherwise), with the latter playing a bigger role over the past 40 years.[4] In this paper, we

[3] Jordà *et al.* (2016) show, however, that the combination of both high public-sector and private-sector debt prior to financial crises tends to exacerbate the negative effects of post-crisis deleveraging.

[4] Romer and Romer (2019) also show that countries with a low debt-to-GDP ratio undertake stronger fiscal expansion after a crisis, even after controlling for interest rates on their debt and other indicators of market access and investors' concerns. Nonetheless, as Blanchard argued in a follow-up comment to this paper: "The debt numbers on which policymakers, rating agencies, and investors base their decisions may have been right for an earlier environment when interest rates were higher and monetary policy was unconstrained. But these debt numbers are no longer the right ones." In that comment, using the same data as Romer and Romer (2019), he shows empirically that a low debt-to-GDP ratio is necessary but not sufficient to achieve the highest credit ranking with a high probability (AAA in standard credit rating agencies). This result suggests that factors beyond debt levels play a substantial role in determining a government's solvency.

build on this literature and extend it by constructing a new measure of public debt sustainability based on the total public debt burden rather than the level of public debt. We use this measure to study the dynamic interplay between financial crises and public debt risks, and we demonstrate that a higher total debt burden at the end of the business cycle exacerbates the severity of the forthcoming crisis. Our results, therefore, suggest that limited fiscal space at the onset of a financial crisis systematically exacerbates the severity of the crisis.

The remainder of the paper proceeds as follows. Section 2 describes the historical evolution of the debt-to-GDP ratio and $r-g$ over the period 1870-2017 for a comprehensive set of advanced economies. It also investigates whether the total public debt burden or its components could be considered leading indicators of financial crises over the past century and a half. Section 3 presents the empirical strategy and the main results of the analysis of the role of public debt burden on crises severity. Possible transmission mechanisms are explored in Section 3.3, while Section 3.4 examines to what extent financial crises impact both the level and the cost of public debt. Section 4 concludes.

2 Public Debt, $r-g$ and financial crises over the last century and a half

2.1 Data and Variables Definition

The main data source is the JST Macrohistory Database (Jordà *et al.*, 2017; `http://www.macrohistory.net/data/`). This database provides annual data on the real economy and the financial sector for 18 advanced economies over 1870-2017. The countries included in the sample are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom (UK) and the United States (US). Alongside data on macroeconomic variables, this database provides dates for economic and financial recessions that will be employed in section 3 to define some of the treatment variables in the empirical analysis such as *normal* and *financial* business cycle peaks. The banking or financial crises chronology for the 18 countries assigns a value of one in the first year that a country experiences a systemic financial crisis and zero otherwise. A banking distress episode is classified as a systemic banking crisis if it involves significant bank failures, banking panics, substantial losses in the banking sector, large-scale recapitalization, or considerable government intervention. Notably, this definition excludes instances where individual or small bank failures or losses lack systemic implications to be coded as a crisis episode. The list of systemic financial crises can be found in Table A1 of Appendix A and will be used to define the variable $Crisis$ in the analysis of section 2.3.

The unit cost of servicing the debt $r-g$. The interest rate we use is the nominal long-term interest rate (usually 5-10 year in maturity) and will be denoted by r.[5]

We use several metrics to compute the output growth series g depending on the role played by this variable in the empirical analyses below. For the description of stylised facts of $r-g$ over the sample period (section 2.2), and for the cases where $r-g$ constitutes the dependent variable in a regression (section 3.4), we employ the 7-year average annual growth rate of future nominal GDP. This metric will be denoted by $\bar{g}$.[6] The reason to use a 7-year window is because the average maturity of public debt for advanced economies has been around 7 years (IMF, 2021). This duration-matched approach is also in line with Hamilton *et al.* (2016), who used moving-averages of future realizations to capture expectations.[7] When $r-g$ serves as a component of our primary treatment measure, as in the regression framework discussed in sections 2.3, 3.1, and 3.3, we instead calculate g based on current output growth. This approach ensures that g, and, consequently, $r-g$ and the total debt burden (defined immediately below), are not derived from GDP realizations beyond time t. Such a derivation would, by definition, mechanically induce endogeneity in regressions where $r-g$ or the total debt burden function as key predetermined treatment variables.[8]

[5] We note that it is innocuous to use nominal or real variables for r and g to compute $r-g$ assuming the same price deflator applies to both variables. We use marginal rather than effective rates to reflect changes in market conditions and to be consistent with, among others, Blanchard (2019).

[6] Jordà *et al.* (2020), Mehrotra and Sergeyev (2021) and Barro (2023) have recently computed similar measures of $r-g$ for empirical purposes. For example, Jordà *et al.* (2020) construct a measure of $r-g$ to study the medium- to long-term effects of wars and pandemics on $r-g$. They define $r-g$ as the difference between the real natural rate and the growth rate of real GDP per capita, using data back from the fourteenth century. Mehrotra and Sergeyev (2021), in turn, compute $r-g$ to provide some stylized facts on such indicator for advanced economies over the last 150 years. They generate this variable as the difference between the real interest rate and the annual growth rate of GDP.

[7] The use of this metric implicitly assumes *perfect foresight* about g, i.e., as if the agents knew what the precise path of the economy is going to be for the duration of the public debt they are acquiring. This unrealistic scenario is on purpose and serves as our benchmark case to discuss stylised facts of $r-g$. The empirical section below will depart from this assumption and will utilise data available to agents at the time of the purchase of the debt.

[8] In Appendix D.1, we show that current output growth is systematically positively highly correlated with the expected future economic growth across different horizons and that therefore it adequately captures future economic growth with the available information at time t. We also conduct separate robustness analyses using alternative measures of long-term economic growth. In Section 3.5, we present results based on the yield spread instead of current economic growth. Additionally, we remove the cyclical component of current GDP growth using a Hodrick-Prescott filter with a smoothing parameter of λ. This approach, available upon request, relies on the pre-crisis trend in GDP growth to estimate the economy's long-term growth before the crisis, yielding similar results. We note that, ideally, we would use forecasts at the peak to capture expected economic growth using information available at the peak. However, while such data have recently become available for many economies, this approach is not feasible within our long-run historical framework, as forecasts were unavailable for most

Total public debt burden TB**.** This variable is defined as the interaction between the stock of public debt as a proportion of GDP, the debt-to-GDP ratio, and the interest-growth differential $(r - g)$.[9]

2.2 Some stylized facts

In the Introduction, we discussed, from a theoretical perspective, the role of the unit cost of public debt in the sustainability of the sovereign debt. This section provides a historical perspective of the evolution of public debt and $r - \bar{g}$. The aim of this analysis is to empirically demonstrate that using TB to assess the sustainability of sovereign debt provides a distinct perspective compared to considering its individual components in isolation, namely, the level of debt or its unit cost.

The historical evolution of the de-meaned public debt and $r - \bar{g}$ over the last 150 years is displayed in Figure 1. The top panel displays the average of each variable for the 18 countries included in the sample. First, we observe that negative interest-growth differentials represent a significant empirical phenomenon throughout the sample period and are not exclusively a characteristic of recent times as many might have thought. Second, the distinct paths displayed by the debt-to-GDP ratio and $r-\bar{g}$ arise as a striking fact in the history of advanced economies.[10] This is further illustrated in the bottom panel of Figure 1 where the scatter plot between the two variables over the sample period reveals the lack of a simple relationship between them.[11] We observe periods where, despite high or very high levels of public debt, the unit cost of debt remained low or very low. Those dynamics contributed to a more manageable total debt burden over the maturity horizon, with significant implications for debt sustainability. Three historical

periods in our sample.

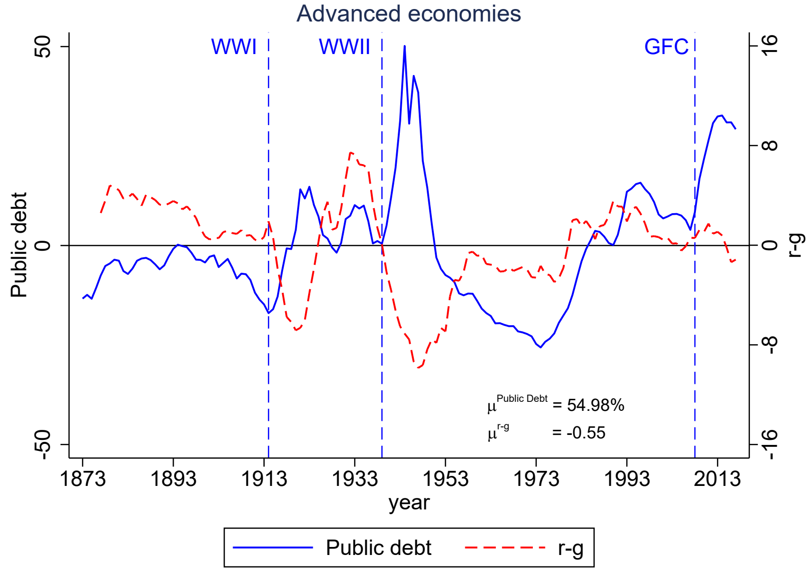
[9] In Figure A1 in Appendix A we present the distribution of TB at the peak of the business cycle for each of the 18 advanced economies. To have an intuition about how the proxies for the total debt burden computed under alternative metrics of g compare to each other over time, Figure A2 in Appendix A depicts the historical evolution of TB using two approaches: one based on the 7-year average annual future real GDP growth ($\bar{g}$), incorporating forward-looking information, and another relying solely on information available at time t, based on current GDP growth. These two series are plotted for the average of all advanced economies in our sample. We refer to the former measure as our benchmark because, in the absence of mechanical endogeneity, we would use it to estimate the total cost of the debt. The main takeaway from Figure A2 is that, overall, and despite some differences, both series behave similarly.

[10] This can be exemplified by the fact that a simple pairwise correlation between the average public debt and the average $r - \bar{g}$, for the set of advanced economies in the sample, yields a negative coefficient (-0.09). This negative correlation becomes even stronger for the US (-0.25). Although this correlation is not meant to be used to draw economic conclusions on the relationship between these two variables, it may be useful to illustrate that advanced countries have faced historical periods when a high (low) debt-to-GDP ratio and a low or even negative (high) $r - \bar{g}$ have simultaneously co-existed.

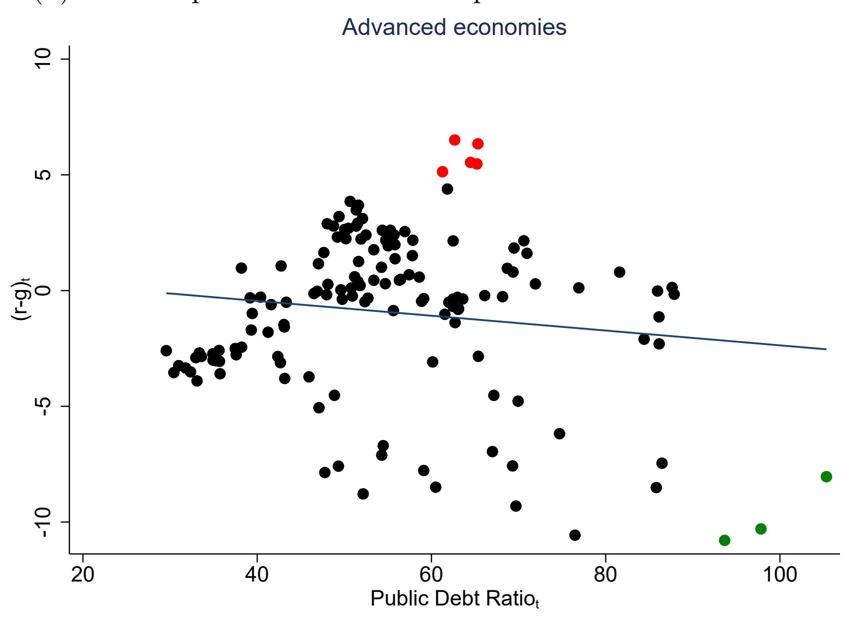
[11] Figure A3 in Appendix A shows the two corresponding graphs for the US. Those graphs illustrate that the features of the series and stylised facts discussed in this section are not the result of aggregating the data across countries.

Figure 1: Public Debt and $r - \bar{g}$.

Panel (a): Historical Evolution of Public Debt and $r - \bar{g}$.



Panel (b): Contemporaneous Relationship between Public Debt and $r - \bar{g}$



Notes: Sample: 1870–2017. For all advanced economies, we use the average historical mean across countries. Panel (a) shows the historical evolution of public debt and $r - \bar{g}$. In Panel (a), both the debt-to-GDP ratio and $r - \bar{g}$ have been de-meaned using the country-specific historical mean. $\mu^{Public\ Debt}$ and $\mu^{r-\bar{g}}$ report the historical mean of the debt-to-GDP ratio and $r - \bar{g}$, respectively. Panel (b) presents scatter plots for the contemporaneous association between the debt-to-GDP ratio and $r - \bar{g}$. In Panel (b), dots in green represent historical episodes where the average debt-to-GDP ratio was above 90%, and dots in red represent historical episodes where $r - \bar{g}$ was above 5%.

episodes serve as illustrative examples of this phenomenon.[12]

[12]See, for instance, Boone *et al.* (2022) for a recent analysis of the role that low interest rates have played in the sustainability of public debt globally over the 21st century.

First, most advanced economies faced a generalized build-up and subsequent stabilization in the debt-to-GDP ratio after World War I (WWI). The trajectory of public debt stands in contrast to that observed for $r - \bar{g}$. This variable experienced a dramatic fall, a later recovery to its pre-war level, and a subsequent upward trend before dropping again in the last years leading up to World War II (WWII). Second, as a consequence of the war itself, most advanced countries experienced a sharp increase in the debt-to-GDP ratio in the post-WWII. This rise in the public debt was followed by a subsequent prolonged period of public deleveraging that took place during the reconstruction boom of the Bretton Woods era. On the other hand, following WWII, advanced economies experienced a sharp decline in $r - \bar{g}$, which took negative values up to the mid-1950s. This fall in $r - \bar{g}$ was followed, as in the years following WWI, by a later recovery to its pre-war levels, later stabilising at around the 3%-4% range. Third, over the last two decades of the sample, the upward trend in the debt-to-GDP ratio has resulted in levels not seen since the end of WWII. These high levels of public debt have simultaneously co-existed with low levels in $r - \bar{g}$, whose progressive fall since the 1990s can be largely explained by the drop in interest rates that has dominated the global landscape in advanced countries over that period.

We have so far demonstrated that advanced economies have recurrently experienced significant economic fluctuations in periods when both a high (low) debt-to-GDP ratio and a low or even negative (high) unit cost of servicing the debt have simultaneously co-existed over the last 150 years. Those stylised facts strengthen the argument to use both the debt-to-GDP ratio and $r - g$ in the measure of the total debt burden to determine the state of public finances. Our core empirical analysis in section 3 will examine the role that those public finance conditions at pre-crisis levels play in influencing the depth and extent of economic recessions and their recovery. Before addressing this issue, we first examine whether TB or any of its components have historically served as precursors to financial crises. We focus on financial crises because theoretical arguments suggest that, in certain contexts, sovereign debt sustainability risks may be be correlated with future financial crises (e.g. Alesina, 2012; Brunnermeier *et al.*, 2016).

2.3 TB prior to financial crises

In the aftermath of the GFC, part of the public debate pointed to public overborrowing as one of the roots behind the triggering of such financial disaster in euro area periphery countries. The central premise of this hypothesis is that episodes of sovereign debt sustainability risks can raise concerns about government solvency, ultimately leading to periods of financial instability through higher debt servicing costs and adverse effects on the banking sector (Alesina, 2012).

While this argument is theoretically valid because periods of public debt instability can lead banks holding government bonds to face solvency threats, there is limited empirical evidence to suggest that this has systematically occurred in advanced economies. In particular, Jordà *et al.* (2016) do not find any empirical link between levels of public debt and financial crisis risk. Therefore, they conclude that historical episodes of public debt instability are not followed by periods of financial instability.

However, given the empirical evidence presented above, one could argue that, since historical periods of high public debt have not consistently aligned with periods of high $r-g$, relying solely on the public debt level as a proxy for debt stability may be insufficient to fully capture the mechanism described above. The literature posits that elevated risks to sovereign debt sustainability may serve as a catalyst for financial and economic instability (see e.g. the mechanisms point out by Alesina (2012), 'debt tolerance limits' (Reinhart and Rogoff, 2010), risk premia (Ghosh *et al.*, 2013), or 'diabolic loops' (Brunnermeier *et al.*, 2016)). It is therefore worth exploring the extent to which the specific relationship between periods of high $r-g$ and/or TB and episodes of financial instability is supported by the data. To this end, we employ an empirical specification designed to capture the potential nonlinear relationship between public finances and financial stability.[13] For that purpose, we first define two indicator variables:

$$Public\ Debt_{i,t}^{High} = \begin{cases} 1 & \text{if} \quad \Delta_5 Public\ Debt_{i,t} > \Delta_5 Public\ Debt_{i,75th\ percentile} \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

$$(r-g)_{i,t}^{High} = \begin{cases} 1 & \text{if} \quad \Delta_5 (r-g)_{i,t} > \Delta_5 (r-g)_{i,75th\ percentile} \\ 0 & \text{otherwise} \end{cases} \tag{2}$$

where $\Delta_5 Public\ Debt$ and $\Delta_5(r-g)$ are the 5-year average annual changes in *Public Debt* and $r-g$ respectively. We therefore use this approach to capture periods in which public debt, $r-g$, or the total debt burden were unusually high relative to their historical distributions and account for the arguments highlighted above. In addition, as suggested by the literature,

[13] This empirical framework also builds on recent macro-finance literature that exploits the historical unconditional distribution of relevant variables, such as private credit, to identify past episodes when these variables reached exceptionally high levels (e.g., Greenwood *et al.*, 2022; Grimm *et al.*, 2023). We note that the aim of this exercise is not to predict a financial crisis as accurately as possible, but rather to examine whether sovereign debt risks, as captured by TB, might be systematically associated with future financial crises.

defining the two indicator variables at time t based on the average annual change of each variable over the preceding five years allows us to account for medium-term fluctuations.

We therefore proceed to study whether episodes of high public debt, $r-g$, or their interaction are systematically linked to changes in the probability of financial crises. For that purpose, we estimate (Jordà, 2005)-style linear forecasting regressions at different horizons:

$$\begin{aligned} Crisis^{cum}_{i,t+1 \text{ to } t+h} = \alpha_{i,h} + \beta_h \ Public\ Debt^{High}_{i,t} + \gamma_h \ (r-g)^{High}_{i,t} + \\ \theta_h \ Public\ Debt^{High}_{i,t} \ \times (r-g)^{High}_{i,t} + \sum_{l=0}^{L} \Gamma_{h,l} \ X_{i,t-l} + \varepsilon_{i,t+1 \text{ to } t+h}, \end{aligned} \quad (3)$$

where $\alpha_{i,h}$ is the country fixed effects, $h = 1, 2, 3$, and $Public\ Debt^{High}_{i,t}$ and $(r-g)^{High}_{i,t}$ are defined above. $X_{i,t}$ includes the five-year average annual real GDP growth, the five-year average annual real CPI inflation, and 1- and 2-year lagged values of the outcome variable ($Crisis_{i,t-1}$ and $Crisis_{i,t-2}$). In the spirit of Greenwood *et al.* (2022), the outcome variable $Crisis^{cum}_{i,t+1 \text{ to } t+h}$ is a dummy variable that takes value 1 if a financial crisis begins in country i in any year between $t+1$ and $t+h$. More formally, let $Crisis_{i,t}$ be an indicator that switches on if a crisis begins in country i in year t, then $Crisis^{cum}_{i,t+1 \text{ to } t+h} = max\{Crisis_{i,t+1}, ..., Crisis_{i,t+h}\}$.[14] This crisis specification deals with uncertainty surrounding crisis definition in at least two dimensions. First, the crisis forecasting literature has shown that the exact year of a crisis cannot be accurately predicted (Kaminsky and Reinhart, 1999; Ward, 2017). However, a small-window (e.g. 2-year and 3-year windows) within which a crisis can happen can be better predicted (e.g. Ward, 2017). Second, this type of crisis-window definition addresses the uncertainty surrounding the exact dates that different crisis databases assign to common crisis events.[15]

Given our crisis definition, the residuals in equation (3) will be serially correlated within the same unit when $h > 1$. Moreover, units in our panel are likely not independent, therefore the residuals in equation (3) are likely contemporaneously correlated across countries in a given point in time. To account for both time-series and cross-section correlation, we compute Driscoll and Kraay (1998) standard errors. In particular, for $h = 1$ we use Driscoll and Kraay (1998) errors with no lags, while for $h > 1$ we do allow arbitrary residual correlation within our panel

[14]Similarly, Schularick *et al.* (2021) define a crisis dummy that takes value 1 if a systemic financial crisis occurs in country i at year t or in the following two years.

[15]For instance, a recent survey on financial crises by Sufi and Taylor (2022) has shown that the three most commonly used crisis databases in the literature (BEKM, RR, and JST) often differ in the date assigned to the crisis.

up to horizon $1.5 \times h$.

Table 1 presents the main results of our prediction exercise. For each horizon h, we report four alternative specifications. The first specification includes only the indicator variable for high public debt as a predictor of financial crises. In the second specification, we augment the regression by adding an indicator variable, defined above, that equals 1 when $r - g$ falls within the top quartile of its distribution. The third specification includes a dummy variable that switches on when both public debt and $r - g$ can be regarded as high at a given point in time, according to rules defined in equations (1) and (2). The latter specification allows us to directly test whether episodes of high total cost of the debt are systematically linked to future financial crises. Finally, in the fourth and last specification, we include to the previous regression the set of controls listed above. All specifications include country-fixed effects.

We note that overall, and regardless of the horizon h, our regressors do not have predictive ability over financial crises. That is, the unconditional and conditional probability of a financial crisis is statistically the same across horizons. This result holds across the four alternative specifications. The first row shows that episodes of high public debt level are negatively related to the probability of future financial crises.[16] In the second and third rows, we test whether episodes of high $r - g$ or TB systematically precede financial crises. Across all forecast horizons h, the results provide very limited empirical evidence that this is the case.

This exercise reveals that neither episodes of high $r - g$ nor episodes of high TB are significantly associated with the future probability of a financial crisis. Therefore, the data does not support the hypothesis that periods of vulnerabilities in the public sector translate systematically into future periods of financial instability. This finding is consistent with the results of Jordà *et al.* (2016), suggesting that the view of financial crises as primarily rooted in weak public finances is not generally supported by historical evidence.

3 Crisis severity: the role of total public debt burden

In this section, we conduct the core empirical analysis of the paper, examining the role of pre-crisis public finances conditions in influencing the depth and extent of economic recessions as

[16] The observed negative empirical relationship between the level of public debt and financial crises is likely a mechanical outcome. Specifically, as demonstrated by Jordà *et al.* (2016), the public debt-to-GDP ratio tends to decrease during economic expansions, preceding both normal recessions and financial crises. Consequently, historical data indicates that the level of public debt has typically been lower prior to crises compared to post-crisis periods.

Table 1: Financial crisis prediction.

	Crisis within 1 year			
	(1)	(2)	(3)	(4)
Public Debt$^{\text{High}}$	-1.62	-1.50	-2.46**	-3.75***
	(1.01)	(0.99)	(1.16)	(1.40)
$(r-g)^{\text{High}}$		-0.79	-1.69	-1.89
		(1.03)	(1.21)	(1.29)
Public Debt$^{\text{High}} \times (r-g)^{\text{High}}$			3.08	3.14
			(1.83)	(1.84)
Unconditional crisis probability, p	3.5%			
Country FE	✓	✓	✓	✓
Controls	✗	✗	✗	✓
R^2	0.01	0.01	0.01	0.02
Observations	1912	1847	1847	1847
	Crisis within 2 years			
	(1)	(2)	(3)	(4)
Public Debt$^{\text{High}}$	-2.94	-2.90	-4.22**	-3.57**
	(1.95)	(1.94)	(1.82)	(1.52)
$(r-g)^{\text{High}}$		-0.32	-1.54	0.91
		(2.33)	(2.83)	(2.38)
Public Debt$^{\text{High}} \times (r-g)^{\text{High}}$			4.19	3.03
			(2.93)	(2.33)
Unconditional crisis probability, p	7.02%			
Country FE	✓	✓	✓	✓
Controls	✗	✗	✗	✓
R^2	0.02	0.02	0.02	0.31
Observations	1894	1829	1829	1829
	Crisis within 3 years			
	(1)	(2)	(3)	(4)
Public Debt$^{\text{High}}$	-5.02	-4.96	-5.32	-3.19
	(2.77)	(2.81)	(2.73)	(1.75)
$(r-g)^{\text{High}}$		-0.89	-1.21	-0.58
		(2.76)	(3.49)	(1.93)
Public Debt$^{\text{High}} \times (r-g)^{\text{High}}$			1.11	-1.43
			(3.61)	(1.91)
Unconditional crisis probability, p	10.58%			
Country FE	✓	✓	✓	✓
Controls	✗	✗	✗	✓
R^2	0.03	0.03	0.03	0.43
Observations	1876	1811	1811	1811

Notes: Sample 1870–2017. Driscoll and Kraay (1998) standard errors in parentheses. Two world wars and 3-year windows around wars are excluded (1911–20; 1936–47). ** $p < 0.05$, *** $p < 0.01$.

well as their recovery. In addition, we analyse plausible transmission channels[17] and conclude the analysis by examining whether economic downturns—both with and without a financial component— generate feedback effects on the determinants of the total debt burden.

3.1 Empirical Design

Our empirical approach builds on the work of Jordà *et al.* (2016). We have a panel setting, where time is denoted by $t = 1, ..., T$, the countries are labelled with $i = 1, ..., M$, and the vector of macroeconomic (outcome) variables of interest has dimension Y. For each variable, $y = 1, ..., Y$, we aim to estimate the change in that variable from the time period corresponding to the peak in economic activity, denoted by $t(p)$, to the time period $t(p) + h$, where $h = 1, 2, ..., H$.

The key predetermined treatment variable will be the total public debt burden for country i at the peak of the business cycle, $TB_{i,t(p)}$, relative to the country-specific historical average level of TB, $\overline{TB_i}$. The other two treatment variables will be the indicators "N" to denote a normal business cycle peak, and "F" to denote a peak associated with a systemic financial crisis, that is, when a crisis labelled as *financial* occurs within ±2 years of the peak.[18] These definitions are consistent with the way financial and normal peaks are specified in the JST Macrohistory Database. Business cycle peak dates are computed using the same method as Jordà *et al.* (2013). They use the Bry and Boschan (1971) algorithm to detect business cycle peaks for all selected advanced economies (except Ireland) over the period 1870-2008. We extend their sample by, first, identifying turning points for Ireland, and second, by expanding the time horizon up to 2017 using the same algorithm.[19] This algorithm uses real GDP per capita to identify local maxima as peaks and local minima as troughs, exactly reproducing the NBER turning points dating for the US and being close to the turning points selected by the CEPR's dating committee for the euro area (Ferroni and Canova, 2021). In what follows, we denote by $t(p)$ the calendar peak year (the year in which the expansion ends).

To investigate the impact of the total debt burden at the onset of a normal or financial crisis on the severity of the crisis, we employ the local projections (LPs) methodology. LPs consist of a sequence of univariate regressions where the outcome variable, measured at progressively

[17]We thank an anonymous reviewer for suggesting this analysis.

[18]A list of the business cycle peaks for both normal and financial recessions can be found in Appendix A Table A2.

[19]We identify business cycle peak dates using the same methodology and annual frequency employed in the JST database. This ensures consistency across the sample and with the existing literature that relies on this database. However, we note that the Bry and Boschan (1971) algorithm was initially designed for monthly data, extended by Harding and Pagan (2002) to quarterly data.

distant horizons, is regressed on the intervention variable—here, a crisis with varying levels of total debt burden—while controlling for a set of covariates. These controls include lags of the outcome along with other exogenous or predetermined variables.[20] Specifically, we estimate the following set of fixed-effects panel regressions:

$$\begin{aligned}\Delta^h y_{i,t(p)+h} =& \alpha_{i,h} + \theta_h^N N_{i,t(p)} + \theta_h^F F_{i,t(p)} + \beta_h^N N_{i,t(p)} \left(TB_{i,t(p)} - \overline{TB_i}\right) + \\ & \beta_h^F F_{i,t(p)} \left(TB_{i,t(p)} - \overline{TB_i}\right) + \sum_{l=1}^{L} \Gamma_{h,l} X_{i,t(p)-l} + \varepsilon_{i,t(p)+h},\end{aligned} \tag{4}$$

where horizon $h = 1, 2, ..., 5$ and $\alpha_{i,h}$ is a country fixed effect. In equation (4), $\Delta^h y_{i,t(p)+h}$ denotes the cumulative change in the key macroeconomic variables we want to examine. For instance, the log of real GDP per capita from the year when the crisis starts, $t(p) + 1$, to h years later, $t(p) + h$. We enhance this dynamic formulation by adding a comprehensive set of control variables, $X_{i,t}$, to account for the macroeconomic environment prior to the recessions. In particular, our baseline specification includes the first and second lags of the growth rate of real GDP per capita, the consumer price index (CPI) inflation rate, the growth rate of real investment per capita, the current-account-to-GDP ratio, the growth rate of real loans per capita, the growth rate of real public debt per capita, and short-term and long-term interest rates.[21] We note that the interaction treatment terms and the control variables are computed relative to their means in the financial and normal recession bins to aide the interpretation of the coefficients of interest.[22] For statistical inference, we employ Driscoll and Kraay (1998) standard errors, which are robust to heteroskedasticity and to spatial and temporal correlation.[23]

[20] Local projections are well-suited to capture asymmetries and nonlinearities in the effects of normal and financial crises, depending on the total debt burden at the recession's onset. Unlike vector autoregressions (VARs), LPs estimate the impulse response function (IRF) directly through a series of regressions at each post-shock horizon. For a detailed overview of local projections and their applications, see Jordà (2005) and Jordà and Taylor (2024).

[21] Our results are robust if we explicitly control for potential domestic crisis anticipation for the US. In particular, our findings remain unchanged after separately including in all the countries' regressions the US GDP and short-term interest rate as additional controls. The results are also robust to alternative lag specifications.

[22] The demeaning of variables ensures that the coefficients θ_h^N and θ_h^F can be naturally interpreted as the average conditional path when all controls, including the total debt burden, are at their mean levels within each crisis bin. Additionally, note that expression (4) does not allow for different control variables for each type of recession. This is because we are not interested in the specific coefficients of those controls given that their primary role is to control for macroeconomic conditions and absorb information, as explained in Jordà (2005) and Jordà *et al.* (2016). While having separate coefficients for normal and financial recessions would be ideal, the practical effect on the estimated response coefficient is relatively small. We have illustrated this in Appendix B, Figure B4, for the case of GDP growth. Moreover, such flexibility would compromise parsimony, which is important given the limitations of the sample size of crises.

[23] The Driscoll-Kraay estimator is analogous to Newey-West standard errors for panel data. Its asymptotics rely on a large time dimension (T) with a fixed or slowly growing cross-sectional dimension (M), which aligns well with our context (see Jordà and Taylor, 2024, for a comprehensive discussion on inference in the LP framework).

We emphasise two key features of the treatment variable $TB_{i,t(p)}$, that are particularly relevant within this empirical framework. First, as noted in section 2.1, the measure of TB used in this section has been constructed based on pre-crisis data, making it predetermined relative to the crisis. Second, we argue that $TB_{i,t(p)}$ is unlikely to anticipate the severity of a crisis, as this would require economic agents to accurately predict both the exact timing of crises and their expected severity.[24] However, we note that while these are necessary conditions for the analysis to be interpreted causally, they are not sufficient unless the empirical framework ensures that the treatment is assigned randomly, which we do not necessarily claim that is the case.

With this specification, our coefficients of interest θ_h^N and θ_h^F trace out the average cumulative outcome response in normal versus financial crisis recessions relative to peak for years 1 to 5 of the recession/recovery period when $TB_{i,t(p)}$ is at its historical country-specific mean. β_h^N and β_h^F, in turn, measure the sensitivity of the selected outcome path to deviations of $TB_{i,t(p)}$ from its historical country-specific mean at the onset of normal versus financial recessions. This analysis, therefore, enables us to investigate whether the total debt burden at the peak of the business cycle influences the severity of crises.

Our baseline sample covers the period from 1870 to 2017, with annual frequency data for 18 advanced economies.[25] To examine whether crisis severity varies based on the total cost of servicing debt, we consider three alternative scenarios: (i) the total cost of servicing the debt at the peak, $TB_{i,t(p)}$, is +1 standard deviation (sd) below the country-specific historical mean (*low debt cost scenario*), (ii) $TB_{i,t(p)}$ is exactly at the country-specific historical mean, and (iii) $TB_{it(p)}$ is +1sd above the country-specific historical mean (*high debt cost scenario*). Therefore, deviations of this variable from its long-run mean at the peak define the experiments through which we evaluate its effects on other macroeconomic outcomes. The value of this variable is held constant for any value of h over which the variables of interest are analysed. Consequently, the trajectory of the recession and subsequent recovery, conditional on information available up

[24] The prediction of financial crises has been shown to be extremely hard with real-time data (Gadea Rivas and Perez-Quiros, 2015; Krishnamurthy and Muir, 2024; Boyarchenko *et al.*, 2022). Indeed, Krishnamurthy and Muir (2024) have shown that financial crises have been historically considered a surprise from the economic agent's perspective. Furthermore, to the best of our knowledge, there is no empirical evidence regarding agents' ability to anticipate the severity of a financial crisis prior to the crisis itself. Therefore, it is not realistic to argue that, with the prediction tools available at that time, economic agents were able to predict the crisis and its expected economic cost and endogenously respond to it.

[25] We use a panel specification in order to use as much data as possible—across time and countries. Doing so is particularly helpful given the scarcity of financial crisis events. An implication of this choice is that we implicitly assume effects are, on average, the same across time and countries. To mitigate concerns about this assumption, we focus on a cross-section of advanced economies, for whom it is reasonable to assume relatively homogeneous effects. This argument is complemented in Appendix B with a time-varying analysis of the coefficients using expanding-window subsamples (see Section 3.5).

to the peak, will depend on the treatment variable. We aim to characterise how these recovery paths evolve as the treatment variable deviates from a baseline level, taken here as the long-run mean at the peak, to experimental levels set at the mean or one standard deviation above or below that mean.

3.2 Empirical Results

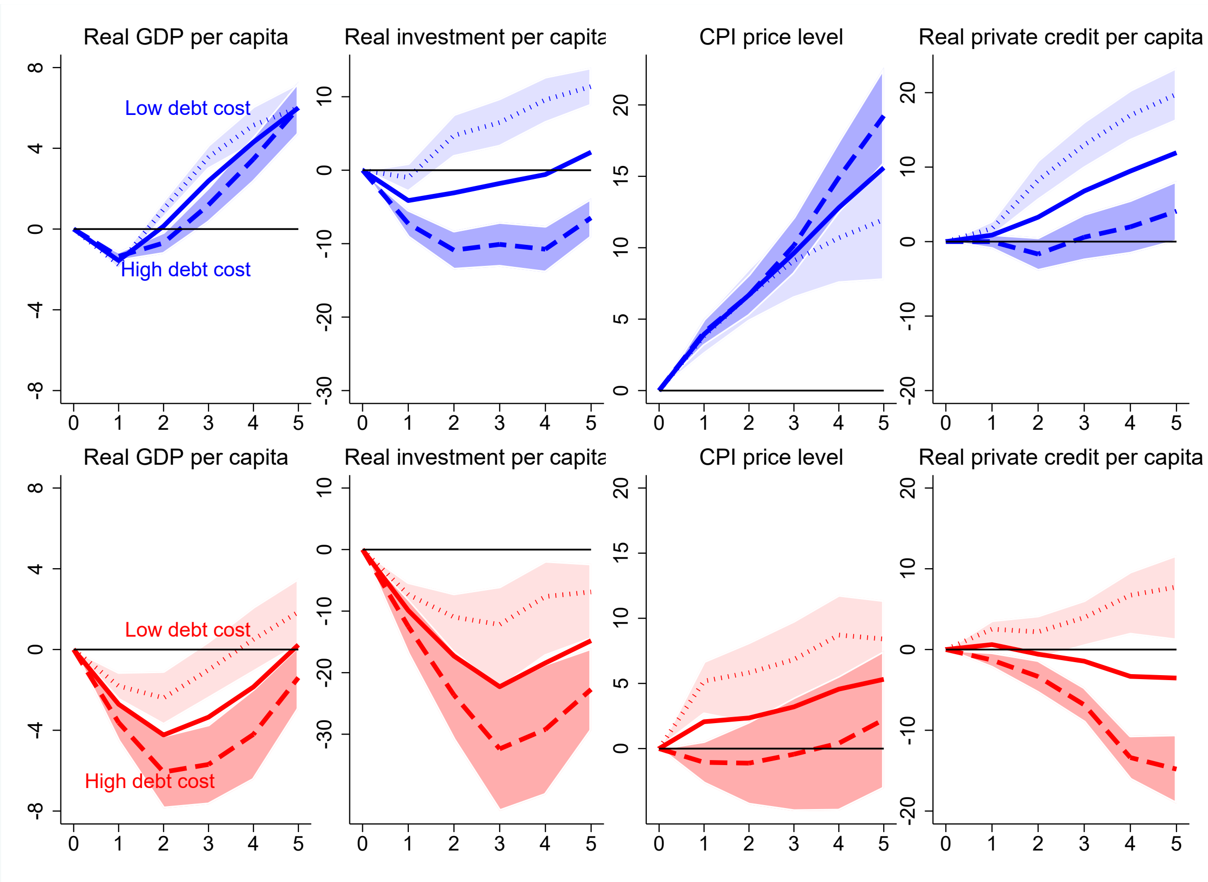
Figure 2 displays the average outcome path in normal versus financial crisis recessions, depending on the size of the total cost of servicing the debt at the business cycle peak $t(p)$. The top panel indicates that the conditional cumulative change in most selected variables of interest from the onset of a normal recession is influenced by initial public debt sustainability risks. In particular, when the pre-crisis debt burden is considered high, the severity of the crisis is worsened. *Ceteris paribus*, the aftermath of normal crises is followed by faster recoveries if there were good public debt conditions at the start of the crisis. The state-dependent normal recession cost is particularly reflected in the investment path following a normal crisis. While investment hardly suffers in recessions when initial debt conditions are favourable, it falls considerably if the onset of the crisis coincides with initial vulnerabilities in the public sector.[26]

The severity of crises, based on the public debt burden at the peak, is more pronounced during financial crisis recessions, as shown in the bottom panel of Figure 2. The path of the real GDP per capita in the aftermath of a financial crisis is sensitive to the pre-crisis public conditions. All else being equal, the larger the initial total cost of servicing the debt, the larger and deeper the output losses associated to the financial crisis. In particular, when the total cost of servicing the debt is low, the economy recovers to its peak level four years after the crisis. However, when the total cost of servicing the debt is high, output stays severely depressed for longer and is below the previous peak even five years following the financial crisis. Moreover, in the latter case, the average fall in GDP relative to its previous peak level is almost twice as large as in the *low debt cost scenario.* The results for real GDP are unambiguous, initial vulnerabilities in the public sector make financial crises more severe on average.

What about the remaining selected macroeconomic outcomes? Investment experiences a

[26] Among the variables analysed, the consumer price index appears to be the least sensitive to public debt conditions during normal recessions. Furthermore, the path of this variable during normal recessions when TB is at average historical values, shows minimal deviation from its trajectory in non-recession periods. It is important to note that this analysis is based on annual frequency data. Consequently, while prices may decline for several months following a business cycle peak, these declines are typically offset, on average, by price increases in subsequent months within the same year. These results align with the findings of Jordà *et al.* (2013) (Section 3.3).

Figure 2: State-Dependent Crises Severity: Normal versus Financial Recessions



Notes: Average cumulative path from the start of the recession of selected macroeconomic variables, depending on the total cost of servicing the debt at the peak. Sample 1870-2017. Results are displayed by type of recession: normal versus financial crises. Each graph shows local projections of the cumulative change relative to peak for years 1–5 of the recession/recovery period under different scenarios. Three scenarios: (i) the country-specific initial total cost of servicing the debt is +1sd below its mean, *low debt cost scenario* (dotted line), (ii) the country-specific initial total cost of servicing the debt is at its mean (solid line), (iii) the country-specific initial total cost of servicing the debt +1sd above its mean, *high debt cost scenario* (dashed line). 68% confidence bands for high debt cost scenarios (dark red and blue) and low debt cost scenarios (light red and blue) are displayed. The top panel refers to normal recessions. The bottom panel refers to financial crisis recessions. These results are conditional on the full set of lagged macroeconomic aggregates, with paths evaluated at the means. Two world wars and 5 year windows around wars are excluded (1909-20; 1934-47).

significant decline, surpassing that of GDP, during financial crisis recessions. Moreover, the investment trajectory following a financial crisis is notably affected by the initial public debt conditions. While in the *low debt cost scenario* the peak of the fall in investment is around 15%, this shortfall in investment increases to almost 35% when the total cost of servicing the public debt at the peak is 1sd above the mean (*high debt cost scenario*). CPI prices and real lending per capita, in turn, are also affected by the pre-crisis public debt sustainability risks. In particular, highly public leveraged financial crises are characterized by deflationary pressures and private credit crunches that last for several years, all else being equal. Tables $C1$ to $C4$ in appendix C present the statistical analysis corresponding to the LPs of the four macroeconomic variables at the five different horizons. The results confirm that, first, average cumulative responses are statistically different across types of recessions, and, second, that in general, the marginal effect of the total debt burden under the low or high scenario within a given type of recession is significantly different relative to the average effect.

In summary, this section demonstrate that initial public debt conditions significantly influence crisis severity. We conjecture that these results could be attributed to the limited fiscal space available to governments when the total sovereign debt burden prior to the crisis is relatively high. In particular, deteriorated public debt conditions at the beginning of the crisis may prevent governments from using countercyclical fiscal policies to foster private and public demand. Limiting, therefore, the government's ability to mitigate the downturn.

3.3 Exploring the Transmission Channels

In this section, we explore plausible mechanisms that may underlie the conjecture that high sovereign debt sustainability risks limits a country's ability to implement macroeconomic stabilisation measures that hinders its capacity to restore growth following a major economic downturn. To explore this, we estimate the response of government spending and revenue during economic downturns under either a high, medium or a low total debt burden at the peak. This analysis is complemented with the estimation of conditional paths for both short- and long-term interest rates to account for the impact on market rates at both ends of the maturity structure.

The empirical analysis of implicit fiscal policies first requires accounting for the automatic responses to business cycle fluctuations, aiming to isolate the discretionary policy decisions made by fiscal authorities. Therefore, we construct cyclically adjusted values for the two fiscal policy variables available in the dataset, namely, overall government expenditure and revenue, using a regression-based approach similar to that of Blanchard (1990) and Alesina and Ardagna (2010).[27] We proceed in three steps. First, following Jordà and Taylor (2016), we calculate the output gap as the deviation of GDP from its trend estimated with a Hodrick-Prescott filter.[28] Second, we use the estimated output gap to calculate cyclically adjusted values for government

[27]The main argument to use this method, as highlighted by Alesina and Ardagna (2010), is its simplicity and transparency in removing cyclical components from expenditure and revenue. We compute the cyclically-adjusted fiscal measures using the output gap, rather than the unemployment rate, as suggested by Fedelino *et al.* (2009) and Ostry *et al.* (2010).

[28]We use a smoothing parameter of $\lambda = 6.25$. The smoothing parameter λ is selected based on the Ravn-Uhlig rule.

expenditure and revenue. The cyclically-adjusted measure for each fiscal variable is defined as the difference between the predicted fiscal value, based on the output gap from the previous period, and the actual value of the fiscal variable in year t.

Third, we use the cyclically-adjusted measures of the two fiscal variables and both the short- and the long-term interest rates as dependent variables in specification (4). The results of the LP estimations are presented in Figure 3 while Tables C5 to C8 in Appendix C include the corresponding point estimates, associated standard errors and hypothesis testing of this analysis. With respect to government expenditure, we observe that the conditional paths when TB is at its mean are similar across different types of recession. However, the paths conditional on high versus low debt scenarios are not. In the case of financial recessions, which are on average deeper and longer than normal ones, the results are consistent with the view that policymakers adopt more limited lax fiscal policies through public expenditure when public finances are worse off. For normal recessions, although government expenditure shows little variation in the fiscal stance, tax revenues are, on average, lower. This pattern is consistent with a more accommodative fiscal policy when governments have stronger public finances at the peak of the business cycle.[29] We offer two observations regarding the trajectory of interest rates. First, interest rates decline more sharply during financial recessions than during normal recessions. Second, in financial recessions, interest rates demonstrate greater flexibility to decrease further in scenarios with lower total debt burdens. This result is consistent with arguments suggesting that better public finances allow governments to finance their debt at a more reduced cost due to lower risk and/or liquidity premia (e.g. Engen and Hubbard, 2004; Laubach, 2011).[30]

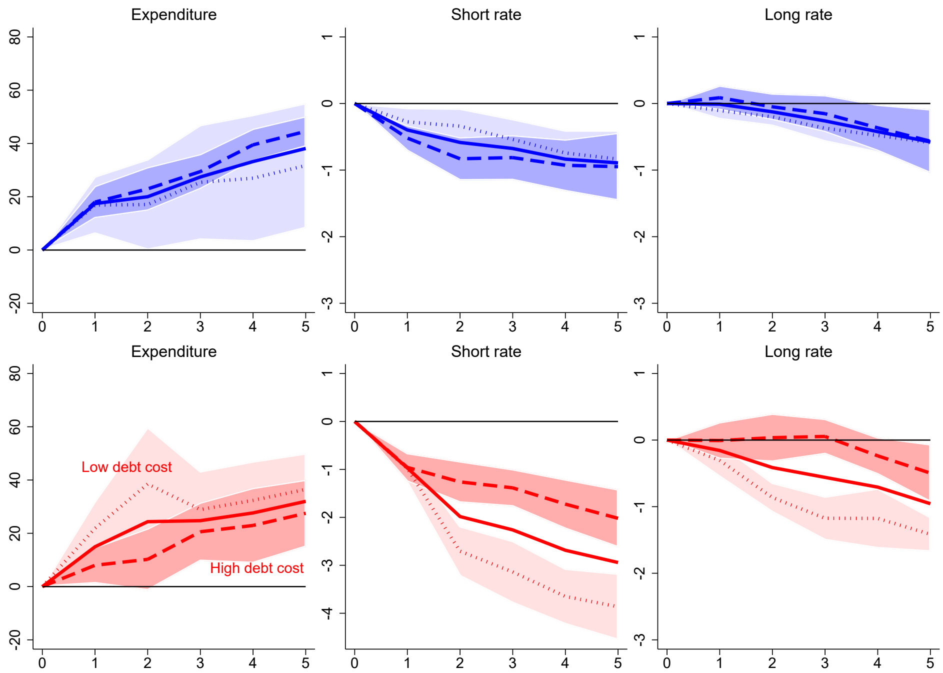
3.4 Total Debt Burden in the Aftermath of Crises

In this section, we have analysed the evolution of a set of key macroeconomic variables under the treatment of economic recessions—classified as either normal or financial—and perturbations in

[29] Uncovering the discretionary fiscal response employing the level of tax revenues is challenging due to factors such as policy outside lags and the lack of historical data on tax rates. Moreover, empirical evidence seems to suggest that the expenditure side of the fiscal policy is the one having a greater impact on output stabilisation when the economy is in recession (see e.g. Auerbach and Gorodnichenko, 2012). Those are the reasons we placed the estimation results for government revenues in appendix C, Figure C1. We note that for the case of financial recessions, tax revenues are lower from the third year of the economic downturn onwards but not for the first two years.

[30] We note that short-term interest rates in the database encompass money market rates, bill rates, interbank rates, and lending rates from financial institutions. Another factor that may help explain the differentiated paths is the potential breakdown of the monetary policy transmission mechanism during more severe financial crises. This disruption can arise from factors such as counterparty risk, liquidity premia, and other distortions, which tend to elevate market interest rates (e.g. Taylor and Williams, 2009; Abbassi and Linzert, 2012; and Heider *et al.*, 2015.)

Figure 3: Plausible Transmission Channels



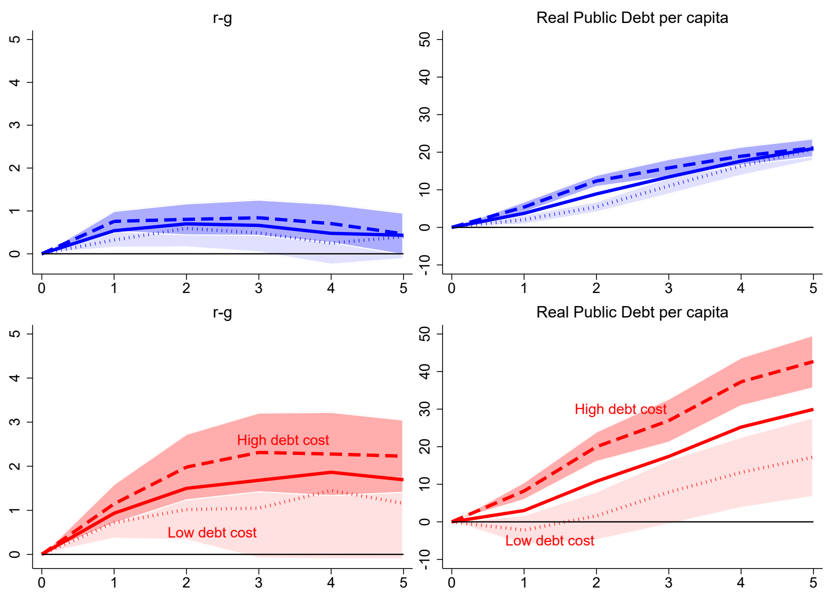
Notes: Average cumulative path from the start of the recession of selected macroeconomic variables, depending on the total cost of servicing the debt at the peak. Sample 1870-2017. Results are displayed by type of recession: normal versus financial crises. Each graph shows local projections of the cumulative change relative to peak for years 1–5 of the recession/recovery period under different scenarios. Three scenarios: (i) the country-specific initial total cost of servicing the debt is +1sd below its mean, *low debt cost scenario* (dotted line), (ii) the country-specific initial total cost of servicing the debt is at its mean (solid line), (iii) the country-specific initial total cost of servicing the debt +1sd above its mean, *high debt cost scenario* (dashed line). 68% confidence bands for high debt cost scenarios (dark red and blue) and low debt cost scenarios (light red and blue) are displayed. The top panel refers to normal recessions. The bottom panel refers to financial crisis recessions. These results are conditional on the full set of lagged macroeconomic aggregates, with paths evaluated at the means. Two world wars and 5 year windows around wars are excluded (1909-20; 1934-47).

the total public debt burden preceding the downturn. We complete our empirical analysis by addressing the same question with respect to the components of the total debt burden. The empirical literature has shown that financial crises are typically followed by substantial increases in public debt (Reinhart and Rogoff, 2009; Jordà *et al.*, 2016). However, little empirical evidence exists on what happens to the other key component of the effective cost of the public debt, $r-\bar{g}$, in the aftermath of economic recessions.[31] Furthermore, to the best of our knowledge, no empirical evidence exists on whether the post-recession trajectories of public debt and the interest-growth differential $(r-\bar{g})$ are influenced by the fiscal position of the government prior to the downturn.

We aim to investigate whether a self-reinforcing feedback mechanism exists between weak-

[31] In this section, we use $\bar{g}$, as we did in Section 2.2, as a proxy for the theoretical concept of medium- to long-term economic growth (g). This choice is driven by the fact that, in this empirical exercise, $r-g$ represents the (endogenous) variable of primary interest that we aim to predict.

Figure 4: Public debt and $r-g$ in the aftermath of normal and financial crises



Notes: Average cumulative path from the start of the recession of selected macroeconomic variables, depending on the total cost of servicing the debt at the peak. Sample 1870-2017. Results are displayed by type of recession: normal versus financial crises. Each graph shows local projections of the cumulative change relative to peak for years 1–5 of the recession/recovery period under different scenarios. Three scenarios: (i) the country-specific initial total cost of servicing the debt is +1sd below its mean, *low debt cost scenario* (dotted line), (ii) the country-specific initial total cost of servicing the debt is at its mean (solid line), (iii) the country-specific initial total cost of servicing the debt +1sd above its mean, *high debt cost scenario* (dashed line). 68% confidence bands for high debt cost scenarios (dark red and blue) and low debt cost scenarios (light red and blue) are displayed. The top panel refers to normal recessions. The bottom panel refers to financial crisis recessions. These results are conditional on the full set of lagged macroeconomic aggregates, with paths evaluated at the means. Two world wars and 5 year windows around wars are excluded (1909-20; 1934-47).

ened public debt conditions at the onset of a crisis and an increased likelihood of sovereign debt crises in its aftermath. We estimate the model specified in equation (4), using the level of real public debt per capita and $r-\bar{g}$ as dependent variables. This approach allows us to estimate the conditional evolution of these variables following normal and financial recessions, based on the level of total debt burden prior to the crisis.

Figure 4 and Tables C9 and C10 in Appendix C present the evolution of public debt and $r-\bar{g}$ in the aftermath of normal versus financial recessions relative to the peak. The results point to a strong link between crises and periods of public debt sustainability risks. In particular, the aftermath of economic recessions, either normal or financial, are followed by significant increases in both public debt and $r-\bar{g}$. The build-up in both public debt and $r-\bar{g}$ following a recession is even larger when the downturn has a financial character and sustainability risks were already relatively higher prior to the downturn.

The risk premium channel coupled with years of economic stagnation following highly leveraged financial crises seem to be reasonable candidates to explain the increase in $r - \bar{g}$. In particular, financial crises with an initial high total debt burden may increase doubts about the solvency of the sovereign, leading governments' lenders to demand a higher compensation in the aftermath of such financial distress. Even though the literature had already demonstrated that economic recessions have a systematic impact on the level of public debt (Reinhart and Rogoff, 2009), we offer a new insight by showing that the state of public finances prior to the economic downturn has an additional marginal effect. Highly publicly leveraged financial crises are followed by a larger accumulation of sovereign debt. This is probably generated by larger fiscal efforts at larger costs that ultimately require larger debt issuance.

Our findings extend the empirical evidence on the economic costs of financial crises by showing that the aftermath of highly leveraged financial disasters is characterised by meaningful jumps in both public debt and $r - \bar{g}$. This explosive cocktail following financial recessions with initial vulnerabilities in the public sector heightens public debt sustainability risks, increasing, consequently, the likelihood of sovereign debt crises after the onset of a financial crisis.

3.5 Robustness Analyses

In this sub-section, we summarise the key findings from a set of robustness exercises. Appendices B and C display the corresponding figures and tables with the results of those exercises.

Expanding-window sample. Our empirical analysis above has employed the whole sample period available in the dataset. This choice is motivated by the need for sufficient variation in our treatment variable—the interaction between the total debt burden and the crises indicators—to attain statistical power. As part of this robustness exercise, we analyse how the results presented in Section 3.2 change as the sample period is progressively extended in increments of thirty years, starting from the initial sample period of 1870–1900.[32] Figure B1 plots the coefficients β_h^N and β_h^F for $h = 1, 3, 5$ for the cumulative response of GDP to perturbations of TB at the peak of the business cycle. We observe that the boxplot displaying the mean and one standard deviation for the final subsample (1870–2017) corresponds to the point representing the respective horizon shown in Figure 2. The analysis yields the following key insights. First, confidence intervals for

[32]We note that the second expanding-window sample is increased by sixty years because within this subsample we do not include the years of the World Wars and the five years around them. Therefore, the increase in the effective sample is around thirty years.

the initial 30-year subsample are notably wide and, as anticipated, progressively narrow as the sample size increases. This observation, combined with the uneven distribution of normal and financial recessions across the entire sample period, suggests that employing a rolling-window framework would be statistically undesirable. Second, with the caveat of limited variation and statistical robustness, the results across subsamples exhibit qualitative consistency. Specifically, (i) the impact of financial crises, relative to normal recessions, is greater in both depth and duration, and (ii) a high total debt burden preceding recessions exacerbates their severity, as indicated by the green dots consistently lying above the red dots.

Average total debt cost previous to the peak. In our baseline analysis conducted in Section 3, we aimed to assess the severity of the crisis depending on the prevailing public debt conditions prior to the crisis. To ensure the robustness of our findings, we examined various alternative definitions of the total debt burden prior to the crisis. Here, we compute the pre-crisis public debt conditions as the average of the total debt burden over a three-year period, that is, at $t(p)$, $t(p) - 1$, and $t(p) - 2$. This approach addresses two potential concerns. First, it mitigates the potential influence of significant variations in the total debt burden at the peak compared to previous years, thus avoiding any bias in our results caused solely by selecting the peak as the benchmark measure for public debt conditions. Second, and related to the previous point, it tests the possibility of agents' anticipation of the posterior crisis severity which could lead to substantial differences between the total debt burden at the peak and the debt burden in the preceding years, particularly if the anticipation window was short (e.g., one year prior to the crisis). We find that, albeit with some slight quantitative differences, our results are qualitatively similar. This result therefore supports that our findings and economic implications are not sensitive to the particular window chosen to construct the total debt burden prior to the crisis. Furthermore, it confirms that there is no signal of systematic crisis severity anticipation in our particular empirical setting.

Unit cost of servicing the debt $r - g$. In our benchmark specification, we use the interaction between the level of public debt and $r - g$, i.e., the total debt burden, to assess public debt conditions. One might question whether any of the components of the total debt burden can, on their own, generate the same outcome. To address this issue, we proceed to estimate the same model, but this time we employ $r - g$ as our measure of public debt conditions at the peak of the business cycle. Our focus is on $r - g$ rather than the level of public debt itself, motivated by the findings of Jordà *et al.* (2016) who, utilizing the same database and model specification, found that high initial levels of public debt, when considered in isolation, do not systematically result in significant deeper financial recessions. Thus, we now estimate the following model:

$$\begin{aligned}\Delta^h y_{i,t(p)+h} =& \alpha_{i,h} + \theta_h^N N_{i,t(p)} + \theta_h^F F_{i,t(p)} + \beta_h^N N_{i,t(p)} \left((r-g)_{i,t(p)} - \overline{(r-g)_i}\right) + \\ & \beta_h^F F_{i,t(p)} \left((r-g)_{i,t(p)} - \overline{(r-g)_i}\right) + \sum_{l=1}^{L} \Gamma_{h,l} X_{i(p),t-l} + \varepsilon_{i,t(p)+h}.\end{aligned} \tag{5}$$

Everything is defined in the same way as in our baseline specification, with the exception that here we have replaced TB with $r-g$ to account for public debt conditions at the peak. Using the specification of Equation 5, we find that a low unit debt cost prior to the crisis somewhat limits the negative impact of financial crises, but the effect is significantly smaller compared to when we consider the interaction of $r-g$ and the level of public debt, i.e, the total debt burden. This sensitivity analysis highlights that the product of $r-g$ with the debt-to-GDP ratio has an impact on economic crisis severity, but not its individual components, taken in isolation.

Alternative measure of g. In our baseline exercise, we used current economic growth to measure g when constructing $TB_{i,t}$ for our empirical analyses. In Appendix D.2, we show that our baseline severity results are robust to an alternative measure of the medium- to long-term economic growth g. In particular, in this robustness exercise, we construct $TB_{i,t(p)}$ for each country in the sample using the yield spread, defined as the difference between long-term and short-term government bond rates. Therefore, we use the yield spread as a leading indicator of future economic growth.[33] We find virtually identical results to our benchmark specification in which $TB_{i,t(p)}$ was constructed based on current economic growth.

4 Conclusions

This paper uses the quasi-universe of advanced countries' economic experiences over the past 150 years to uncover new insights into the relationship between financial and nonfinancial crises and sovereign debt sustainability risks. Our empirical analysis includes several contributions. First, we incorporate both the level and the cost $(r-g)$ of public debt to account for public

[33]This way, we construct an alternative measure of the expected total public debt burden with the available information prior to the recession. We do so after showing that the slope of the yield curve spread can significantly predict future economic growth using our long-run panel of 18 advanced economies. See Appendix D.2.

finances conditions. This is supported by recent theoretical literature, which argues that both factors should be considered when evaluating sovereign debt sustainability. In this context, we document that the level of public debt and the interest-growth differential ($r-g$) convey distinct information about the state of public finances. This empirical evidence strengthens the case for incorporating both factors into the analysis of debt sustainability risks and economic recessions.

Our second contribution examines the impact of the total sovereign debt burden, defined as the product of the debt level and the unit cost $r - g$, on macroeconomic outcomes during the crisis. The empirical findings suggest that a low or high overall public debt burden prior to the economic downturn will have different implications in terms of its severity. In particular, the aftermath of a financial crisis preceded by a high public debt burden will be characterised by deeper and longer economic declines, deflationary pressures and credit slumps. An additional analysis about plausible transmission mechanisms highlights the importance of having enough fiscal space, in case a financial crisis materialises, so that the government can mitigate the downturn through countercyclical fiscal policies.

In our third and final contribution, we show that whilst episodes of high total public debt burden do not systematically precede upcoming financial crises, the latter, when they occur, make sovereign debt crises more likely. In particular, the aftermath of financial crises is usually characterised not only by build-ups in levels of public debt, but also by increases in $r - g$, and that this effect is magnified when the total debt burden is relatively high. This empirical finding points to financial stability as an additional element to enhance public debt stability.

Declaration of Interest: None

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Appendix

A Crisis dates, Recession Peak dates and Summary Statistics

Table A1: Systemic Financial Crises, 1870-2017

Australia	1893, 1989
Belgium	1870, 1876, 1885, 1925, 1931, 1934, 1939, 2008
Canada	1907
Denmark	1877, 1885, 1908, 1921, 1987, 2008
Finland	1877, 1900, 1921, 1931, 1991
France	1882, 1889, 1930, 2008
Germany	1873, 1891, 1901, 1931, 2008
Ireland	2008
Italy	1873, 1887, 1893, 1907, 1921, 1930, 1935, 1990, 2008
Japan	1871, 1890, 1901, 1907, 1920, 1927, 1997
Netherlands	1921, 2008
Norway	1899, 1922, 1931, 1988
Portugal	1890, 1920, 1923, 1931
Spain	1883, 1890, 1913, 1920, 1924, 1931, 1977, 2008
Sweden	1878, 1907, 1922, 1931, 1991, 2008
Switzerland	1870, 1910, 1931, 1991, 2008
United Kingdom	1890, 1974, 1991, 2007
United States	1873, 1893, 1907, 1930, 1984, 2007

Notes: Systemic crisis dates used in the local projection models estimated in subsection 2.3. Source: JST Macrohistory Database (Jordà *et al.*, 2017; `http://www.macrohistory.net/data/`)

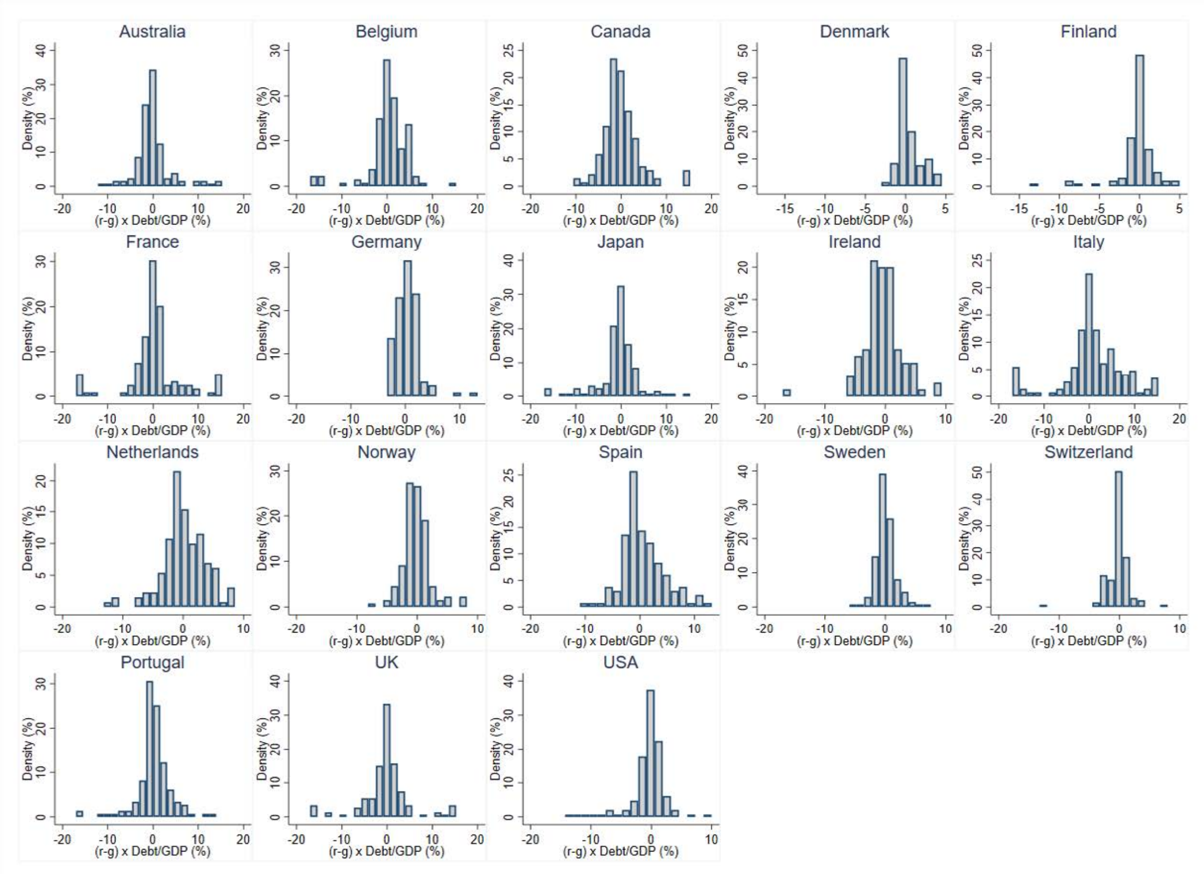
Table A2: Normal and Financial Peaks, 1870-2017

Australia	N	1875	1878	1881	1883	1885	1887	1889	1896	1898	1900	1904
		1910	1913	1926	1938	1943	1951	1956	1961	1973	1976	1981
		2008										
	F	1891	1894	1989								
Canada	N	1891	1871	1877	1882	1884	1888	1894	1903	1913	1917	1928
		1944	1947	1953	1956	1981	1989	2007				
	F	1874	1907									
Switzerland	N	1875	1880	1886	1890	1893	1899	1902	1906	1912	1916	1920
		1933	1939	1947	1951	1957	1974	1981	1994	2001		
	F	1871	1929	1990	2008							
Germany	N	1879	1898	1905	1913	1922	1943	1966	1974	1980	1992	2001
	F	1875	1890	1908	1928	2008						
Denmark	N	1870	1880	1887	1911	1914	1916	1923	1939	1944	1950	1962
		1973	1979	1992								
	F	1872	1876	1883	1920	1931	1987	2007				
Spain	N	1873	1877	1892	1894	1901	1909	1911	1916	1927	1932	1935
		1940	1944	1947	1952	1958	1974	1980	1992			
	F	1883	1889	1913	1925	1929	1978	2007				
France	N	1872	1874	1892	1894	1896	1900	1905	1907	1909	1912	1916
		1920	1926	1933	1937	1939	1942	1974	1992			
	F	1882	1929	2007								
United Kingdom	N	1871	1875	1877	1883	1896	1899	1902	1907	1918	1925	1929
		1938	1943	1951	1957	1979						
	F	1873	1889	1973	1990	2007						
Italy	N	1870	1883	1897	1918	1923	1925	1932	1939	1974	2002	2004
	F	1874	1887	1891	1929	2007	1992					
Japan	N	1875	1877	1880	1887	1890	1892	1895	1898	1903	1919	1921
		1929	1933	1940	1973	2001	2007					
	F	1882	1901	1907	1913	1925	1997					
Netherlands	N	1870	1873	1877	1889	1894	1899	1902	1913	1929	1957	1974
		1980	2001									
	F	1892	1906	1937	1939	2008						
Norway	N	1876	1881	1885	1893	1902	1916	1923	1939	1941	1957	1981
		2007										
	F	1897	1920	1930	1987							
Sweden	N	1873	1876	1881	1883	1885	1888	1890	1899	1901	1904	1913
		1916	1924	1939	1976	1980						
	F	1879	1907	1920	1930	1990	2007					
United States	N	1875	1887	1889	1895	1901	1909	1913	1916	1918	1926	1937
		1944	1948	1953	1957	1969	1973	1979	1981	1990	2000	
	F	1873	1882	1892	1906	1929	2007					
Belgium	N	1872	1874	1887	1890	1900	1913	1916	1942	1951	1957	1974
		1980	1992									
	F	1870	1883	1926	1930	1937	2008					
Finland	N	1870	1883	1890	1898	1907	1913	1916	1938	1941	1943	1952
		1957	1975	2008								
	F	1876	1900	1929	1989							

Portugal	N	1870	1973	1877	1888	1893	1900	1904	1907	1912	1914	1916
		1925	1927	1934	1937	1939	1941	1944	1947	1951	1973	1982
		1992	2002	2004	2010							
	F	1890	1923	1929	2007							
Ireland	N	1922	1931	1936	1939	1946	1955	1974	1982	2010		
	F	2007										

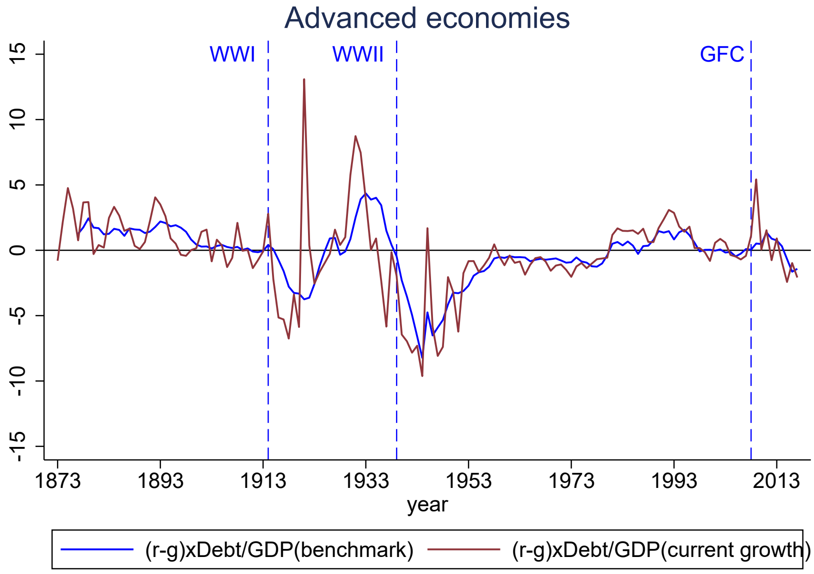
Notes: Normal and financial business cycle peaks used in the models estimated in section 3 and subsection 3.4. Source: Jordà *et al.* (2013) + Authors' estimation.

Figure A1: Distribution of the total cost of the debt $TB_{i,t}$



Notes: Distribution of $TB_{i,t}$ for each of the 18 advanced-economy in our sample. Sample 1870-2017.

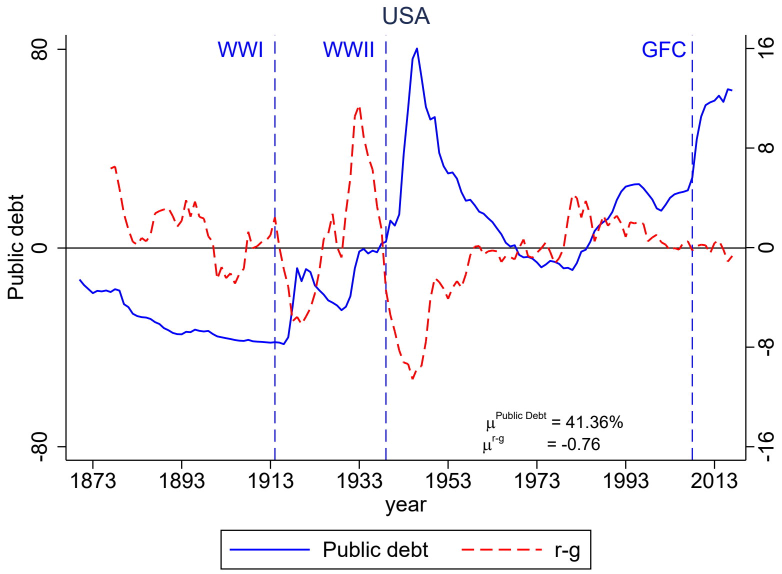
Figure A2: Historical evolution of the total cost of the debt TB



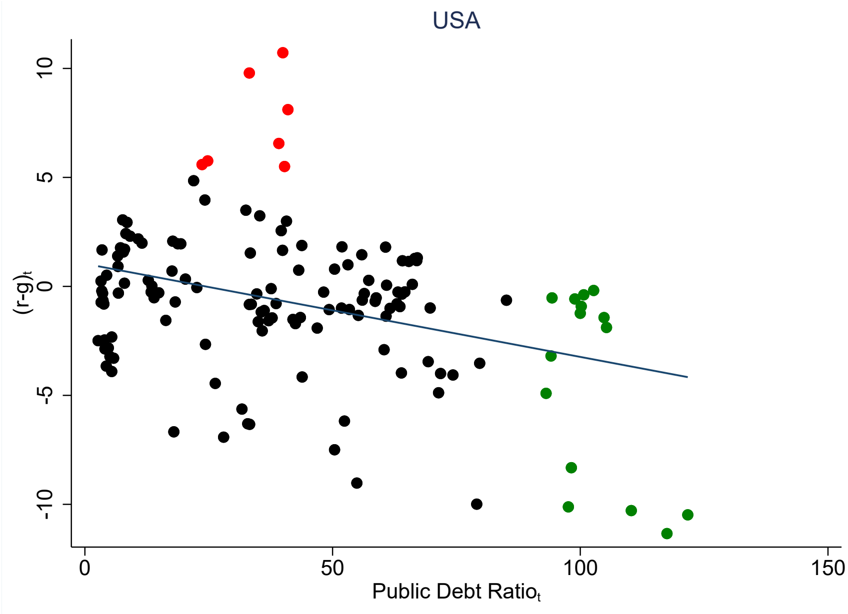
Notes: $TB = (r - g)$ x $Debt/GDP$. We plot two measures: the benchmark measure, where $(r - g)$ has been constructed using the 7-year average annual growth rate of future real GDP (as explained in section 2) and our proposed measured for the empirical analysis, where $(r - g)$ has been constructing using current output growth. For all advances economies, we use the average historical mean across countries.

Figure A3: Public Debt and $r - \bar{g}$.

Panel (a): Historical Evolution of Public Debt and $r - \bar{g}$.



Panel (b): Contemporaneous Relationship between Public Debt and $r - \bar{g}$



Notes: Sample: 1870–2017. Panel (a) shows the historical evolution of public debt and $r - \bar{g}$. In Panel (a), both the debt-to-GDP ratio and $r - \bar{g}$ have been de-meaned using the country-specific historical mean. $\mu^{Public\ Debt}$ and $\mu^{r-\bar{g}}$ report the historical mean of the debt-to-GDP ratio and $r - \bar{g}$, respectively. Panel (b) presents scatter plots for the contemporaneous association between the debt-to-GDP ratio and $r - \bar{g}$. In Panel (b), dots in green represent historical episodes where the average debt-to-GDP ratio was above 90%, and dots in red represent historical episodes where $r - \bar{g}$ was above 5%.

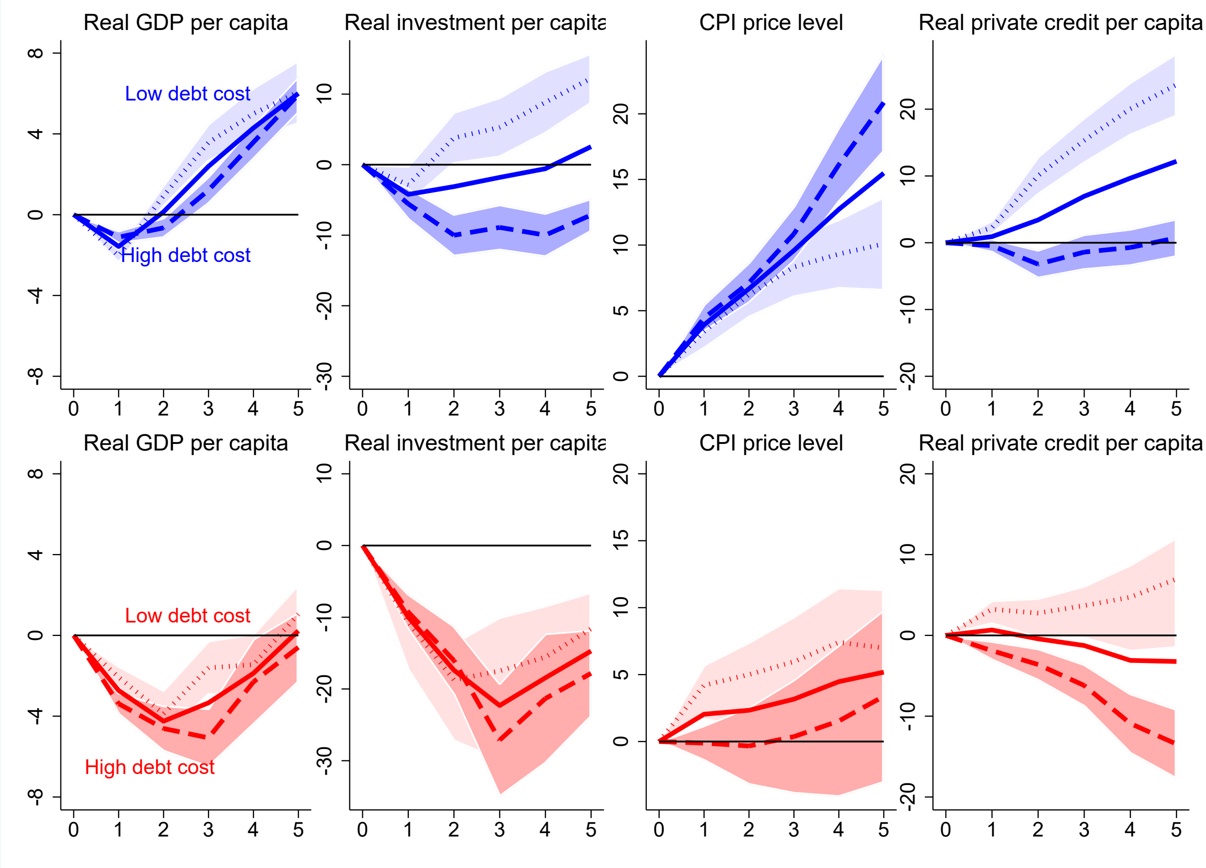
B Sensitivity Checks

In this appendix, we present our findings from some of the robustness exercises described in sub-section 3.5.

Figure B1: Sensitivity Analysis: Expanding-window sample

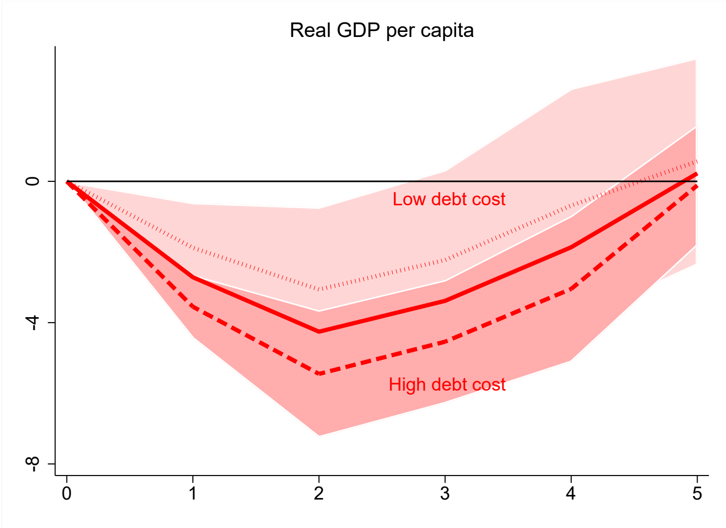
Notes: Average cumulative output path at horizons $h = 1, 3, 5$ years from the start of the recession, depending on the total debt burden at its peak. Two scenarios: (i) the country-specific initial total cost of servicing the debt is 1 standard deviation below its mean, the *low debt cost scenario* (green square); (ii) the country-specific initial total cost of servicing the debt is 1 standard deviation above its mean, the *high debt cost scenario* (red circle). Markers represent point estimates, while whiskers indicate the 68% confidence interval. Four subsamples: (1) 1870-1900 (2) 1870-1960, (3) 1870-1990, (4) 1870-2017.

Figure B2: Sensitivity Analysis: 3-year average total cost of servicing the debt prior to the peak



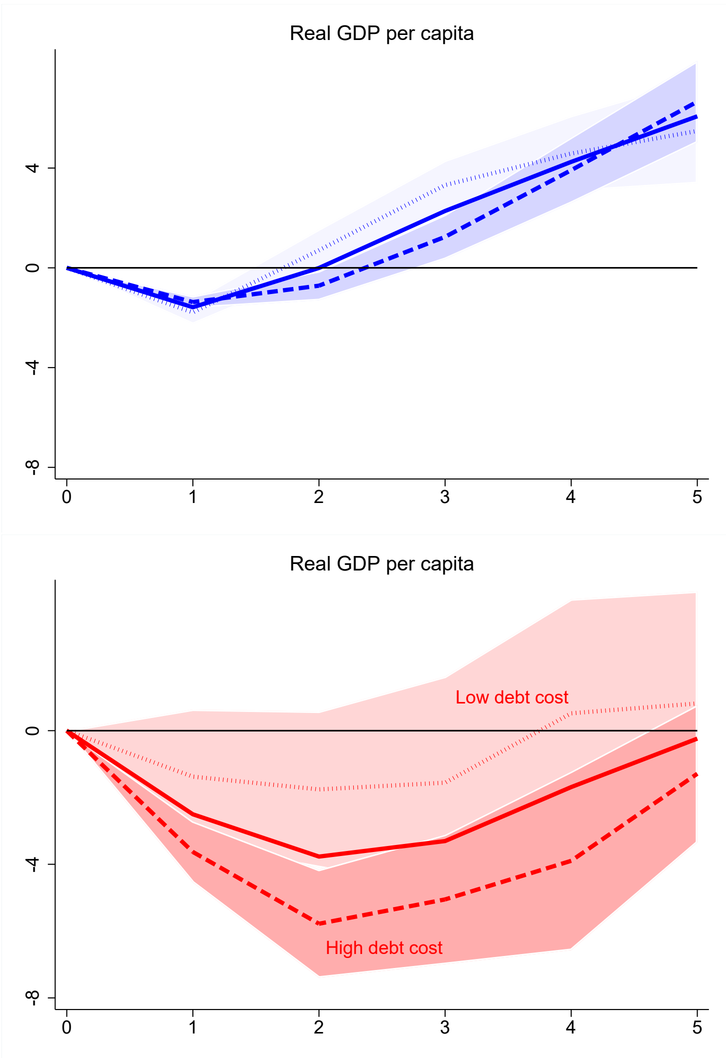
Notes: Average cumulative path from the start of the recession of selected macroeconomic variables, depending on the 3-year average total cost of servicing the debt prior to the peak. Sample 1870-2017. Results are displayed by type of recession: normal versus financial crises. Each graph shows local projections of the cumulative change relative to peak for years 1–5 of the recession/recovery period under different scenarios. Three scenarios: (i) the country-specific initial total cost of servicing the debt is +1sd below its mean, *low debt cost scenario* (dotted line), (ii) the country-specific initial total cost of servicing the debt is at its mean (solid line), (iii) the country-specific initial total cost of servicing the debt +1sd above its mean, *high debt cost scenario* (dashed line). 68% confidence bands for high debt cost scenarios (dark red and blue) and low debt cost scenarios (light red and blue) are displayed. The top panel refers to normal recessions. The bottom panel refers to financial crisis recessions. These results are conditional on the full set of lagged macroeconomic aggregates, with paths evaluated at the means. Two world wars and 5 year windows around wars are excluded (1909-20; 1934-47).

Figure B3: Sensitivity Analysis: considering only $r - g$



Notes: Average cumulative output path from the start of the recession, depending on the unit cost of servicing the debt at the peak. Sample 1870-2017. The graph shows local projections of the cumulative change relative to peak for years 1–5 of the recession/recovery period under different scenarios. Three scenarios: (i) the country-specific initial unit cost of servicing the debt is +1sd below its mean, *low unit debt cost scenario* (dotted line), (ii) the country-specific initial unit cost of servicing the debt is at its mean, (solid line), (iii) the country-specific initial unit cost of servicing the debt +1sd above its mean, *high unit debt cost scenario* (dashed line). 68% confidence bands for high debt cost scenarios (dark red) and low debt cost scenarios (light red) are displayed. These results are conditional on the full set of lagged macroeconomic aggregates, with paths evaluated at the means. Two world wars and 5 year windows around wars are excluded (1909-20; 1934-47).

Figure B4: Sensitivity Analysis: Crisis-specific Controls



Notes: Average cumulative output path from the start of the recession, depending on the total debt burden at the peak. Sample 1870-2017. Results are displayed by type of recession: normal versus financial crises. Each graph shows local projections of the cumulative change relative to peak for years 1–5 of the recession/recovery period under different scenarios. Three scenarios: (i) the country-specific initial total cost of servicing the debt is +1sd below its mean, *low debt cost scenario* (dotted line), (ii) the country-specific initial total cost of servicing the debt is at its mean (solid line), (iii) the country-specific initial total cost of servicing the debt +1sd above its mean, *high debt cost scenario* (dashed line). 68% confidence bands for high debt cost scenarios (dark red and blue) and low debt cost scenarios (light red and blue) are displayed. The top panel refers to normal recessions. The bottom panel refers to financial crisis recessions. These results are conditional on the full set of lagged macroeconomic aggregates, with paths evaluated at the means. Two world wars and 5 year windows around wars are excluded (1909-20; 1934-47).

C Other Results

Table C1: Response of Real GDP per capita

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	-1.56***	0.14	2.38***	4.30***	6.01***
	(0.16)	(0.37)	(0.63)	(0.92)	(1.08)
Financial recession, θ_h^F	-2.71***	-4.23***	-3.35***	-1.85**	0.23
	(0.45)	(0.68)	(0.99)	(1.05)	(0.87)
Total Debt Cost Normal, β_h^N	0.05ˆ	-0.21***	-0.30***	-0.21**	-0.00
	(0.05)	(0.08)	(0.10)	(0.12)	(0.16)
Total Debt Cost Financial, β_h^F	-0.23ˆ	-0.46ˆ	-0.58**	-0.59ˆ	-0.41ˆ
	(0.17)	(0.36)	(0.35)	(0.41)	(0.34)
R^2	0.58	0.36	0.37	0.38	0.47
$\theta_h^N = \theta_h^F$, *p-value*	0.01	0.00	0.00	0.00	0.00

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ $p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of growth in real GDP per capita for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C2: Response of Real Investment per capita

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	-4.13***	-3.08**	-1.80ˆ	-0.59	2.45ˆ
	(1.07)	(1.34)	(1.78)	(1.97)	(1.64)
Financial recession, θ_h^F	-9.88***	-17.30***	-22.28***	-18.42***	-14.80***
	(2.51)	(3.43)	(6.44)	(5.79)	(3.74)
Total Cost Normal, β_h^N	-0.78**	-1.95***	-2.07***	-2.53***	-2.23***
	(0.39)	(0.61)	(0.65)	(0.61)	(0.51)
Total Cost Financial, β_h^F	-0.65ˆ	-1.58ˆ	-2.52**	-2.70**	-1.98**
	(0.60)	(1.17)	(1.34)	(1.57)	(1.08)
R^2	0.38	0.46	0.33	0.31	0.35
$\theta_h^N = \theta_h^F$, *p-value*	0.04	0.00	0.01	0.01	0.00

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ $p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of growth in real investment per capita for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C3: Response of CPI price level

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	3.94***	6.69***	9.63***	12.81***	15.61***
	(0.66)	(1.19)	(1.75)	(2.26)	(2.84)
Financial recession, θ_h^F	2.06***	2.35ˆ	3.20ˆ	4.56**	5.32**
	(0.68)	(1.45)	(1.98)	(2.36)	(2.54)
Total Cost Normal, β_h^N	0.03	-0.00	0.13	0.53ˆ	0.90ˆ
	(0.22)	(0.29)	(0.38)	(0.44)	(0.64)
Total Cost Financial, β_h^F	-0.78**	-0.87ˆ	-0.91ˆ	-1.04ˆ	-0.77
	(0.35)	(0.59)	(0.79)	(0.88)	(0.86)
R^2	0.69	0.68	0.66	0.66	0.67
$\theta_h^N = \theta_h^F$, *p-value*	0.01	0.00	0.00	0.00	0.00

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ$p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of growth in CPI price level for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C4: Response of Real private credit per capita

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	0.87ˆ	3.28***	6.79***	9.46***	11.94***
	(0.62)	(1.19)	(1.89)	(2.53)	(3.11)
Financial recession, θ_h^F	0.61ˆ	-0.58	-1.44ˆ	-3.33ˆ	-3.53ˆ
	(0.58)	(0.74)	(1.23)	(2.11)	(3.13)
Total Cost Normal, β_h^N	-0.22ˆ	-1.24**	-1.55**	-1.87***	-1.96***
	(0.20)	(0.54)	(0.62)	(0.60)	(0.55)
Total Cost Financial, β_h^F	-0.48**	-0.69ˆ	-1.35***	-2.51***	-2.81***
	(0.21)	(0.47)	(0.44)	(0.47)	(0.67)
R^2	0.29	0.36	0.45	0.44	0.44
$\theta_h^N = \theta_h^F$, *p-value*	0.75	0.01	0.00	0.00	0.00

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ $p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of growth in real private credit per capita for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C5: Response of Expenditure

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	17.43***	20.01***	27.43***	33.22***	38.13***
	(3.58)	(4.75)	(5.76)	(5.86)	(6.12)
Financial recession, θ_h^F	14.94***	24.37***	24.75***	27.66***	32.00***
	(1.71)	(2.75)	(3.63)	(4.73)	(4.07)
Total Cost Normal, β_h^N	0.27	1.40	0.97	3.04	3.12
	(2.45)	(3.80)	(4.06)	(4.48)	(4.27)
Total Cost Financial, β_h^F	-3.30ˆ	-6.73ˆ	-1.98	-2.24	-2.13
	(2.95)	(5.65)	(4.35)	(5.11)	(4.64)
R^2	0.89	0.87	0.88	0.89	0.91
$\theta_h^N = \theta_h^F$, *p-value*	0.61	0.54	0.76	0.54	0.51

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ $p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of expenditure for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C6: Response of Revenue

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	4.76**	14.63**	29.57***	41.06***	52.85***
	(2.31)	(5.77)	(9.39)	(8.77)	(8.53)
Financial recession, θ_h^F	4.78**	-0.42	-8.47ˆ	-8.93	7.22
	(2.25)	(3.01)	(8.21)	(12.56)	(7.50)
Total Cost Normal, β_h^N	3.26ˆ	4.33ˆ	6.80ˆ	10.56ˆ	9.93ˆ
	(2.88)	(3.12)	(3.94)	(6.58)	(6.41)
Total Cost Financial, β_h^F	-3.25ˆ	-6.50ˆ	1.76	5.52	1.31
	(1.96)	(3.79)	(4.54)	(5.75)	(4.12)
R^2	0.82	0.81	0.78	0.78	0.87
$\theta_h^N = \theta_h^F$, *p-value*	0.99	0.06	0.01	0.00	0.00

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ $p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of revenue for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C7: Response of Short-Term Interest Rate

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	-0.40**	-0.58**	-0.68**	-0.84**	-0.89**
	(0.17)	(0.24)	(0.27)	(0.33)	(0.42)
Financial recession, θ_h^F	-0.97***	-1.98***	-2.26***	-2.69***	-2.94***
	(0.17)	(0.43)	(0.44)	(0.49)	(0.62)
Total Cost Normal, β_h^N	-0.03ˆ	-0.06ˆ	-0.03	-0.02	-0.01
	(0.03)	(0.04)	(0.05)	(0.04)	(0.05)
Total Cost Financial, β_h^F	0.00	0.18***	0.22***	0.24***	0.23***
	(0.06)	(0.05)	(0.08)	(0.06)	(0.05)
R^2	0.49	0.45	0.54	0.54	0.50
$\theta_h^N = \theta_h^F$, *p-value*	0.02	0.00	0.00	0.00	0.00

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ$p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of short term interest rate for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C8: Response of Long-Term Interest Rate

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	-0.01	-0.12	-0.26ˆ	-0.42ˆ	-0.58**
	(0.14)	(0.13)	(0.19)	(0.26)	(0.34)
Financial recession, θ_h^F	-0.16	-0.41ˆ	-0.56**	-0.71***	-0.96***
	(0.16)	(0.25)	(0.25)	(0.25)	(0.27)
Total Cost Normal, β_h^N	0.02ˆ	0.02	0.03	0.01	0.00
	(0.02)	(0.03)	(0.04)	(0.04)	(0.05)
Total Cost Financial, β_h^F	0.04	0.11***	0.15***	0.12**	0.11**
	(0.05)	(0.04)	(0.04)	(0.07)	(0.06)
R^2	0.23	0.28	0.32	0.36	0.42
$\theta_h^N = \theta_h^F$, *p-value*	0.28	0.18	0.22	0.37	0.13

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ$p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of long term interest rate for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C9: Response of Real public debt per capita

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	3.73***	8.90***	13.42***	17.64***	20.97***
	(1.10)	(1.44)	(1.85)	(2.08)	(2.22)
Financial recession, θ_h^F	3.00ˆ	10.79***	17.41***	25.22***	29.96***
	(2.43)	(4.01)	(4.85)	(5.95)	(6.42)
Total Cost Normal, β_h^N	0.42**	0.86***	0.60ˆ	0.33	0.05
	(0.25)	(0.19)	(0.37)	(0.39)	(0.43)
Total Cost Financial, β_h^F	1.30**	2.30**	2.38**	3.01**	3.17**
	(0.58)	(0.93)	(1.40)	(1.40)	(1.60)
R^2	0.37	0.47	0.54	0.60	0.63
$\theta_h^N = \theta_h^F$, *p-value*	0.74	0.61	0.37	0.17	0.15

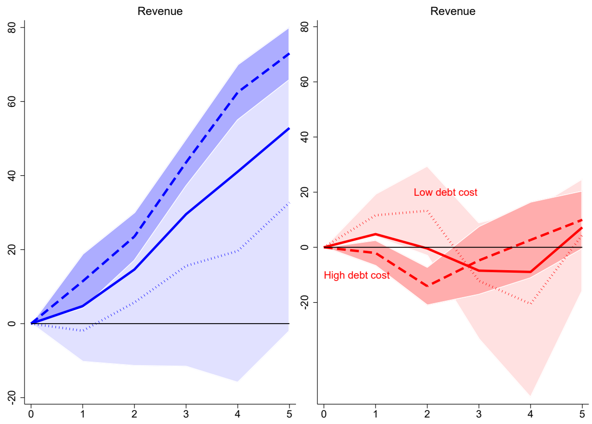
Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ $p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of growth in real public debt per capita for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Table C10: Response of r-g

	Year 1	Year 2	Year 3	Year 4	Year 5
Normal recession, θ_h^N	0.54***	0.70***	0.66**	0.48ˆ	0.43ˆ
	(0.18)	(0.24)	(0.33)	(0.39)	(0.37)
Financial recession, θ_h^F	0.93***	1.50***	1.68**	1.86**	1.69**
	(0.27)	(0.48)	(0.66)	(0.82)	(0.74)
Total Cost Normal, β_h^N	0.07**	0.03	0.06	0.07	0.01
	(0.04)	(0.11)	(0.10)	(0.09)	(0.11)
Total Cost Financial, β_h^F	0.07	0.16	0.20	0.13	0.17
	(0.10)	(0.18)	(0.26)	(0.32)	(0.25)
R^2	0.41	0.39	0.35	0.32	0.41
$\theta_h^N = \theta_h^F$, *p-value*	0.18	0.10	0.13	0.09	0.09

Notes: Driscoll and Kraay standard errors are in parentheses with: ˆ $p < 0.32$, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The results correspond to local projections of r-g for years 1-5 of the recession/recovery. Total debt cost refers to the marginal effect of total debt cost on the average path in normal and financial recessions. Therefore, If the total debt cost is one standard deviation above the mean, the path of the dependent variable in a financial crisis recession can be calculated by adding the financial recession coefficient to the product of the total debt cost financial coefficient and one standard deviation. In both financial and normal recessions, one standard deviation in total debt cost are approximately 4. $\theta_h^N = \theta_h^F$ tests the null hypothesis that the coefficients for the average and marginal total debt cost cases are the same.

Figure C1



Notes: Average revenue cumulative path from the start of the recession, depending on the total cost of servicing the debt prior to the peak. Sample 1870-2017. Results are displayed by type of recession: normal versus financial crises. Each graph shows local projections of the cumulative change relative to peak for years 1–5 of the recession/recovery period under different scenarios. Three scenarios: (i) the country-specific initial total cost of servicing the debt is +1sd below its mean, *low debt cost scenario* (dotted line), (ii) the country-specific initial total cost of servicing the debt is at its mean (solid line), (iii) the country-specific initial total cost of servicing the debt +1sd above its mean, *high debt cost scenario* (dashed line). 68% confidence bands for high debt cost scenarios (dark red and blue) and low debt cost scenarios (light red and blue) are displayed. The left panel refers to normal recessions. The right panel refers to financial crisis recessions. These results are conditional on the full set of lagged macroeconomic aggregates, with paths evaluated at the means. Two world wars and 5 year windows around wars are excluded (1909-20; 1934-47).

D Other analyses

D.1 Current economic growth predicting future economic growth

In our baseline exercise, we use current economic growth to measure the long-term economic growth g when constructing the $TB_{i,t}$ used in our empirical analyses. In this appendix, we show that current economic growth does a good job capturing future economic growth. We therefore test the ability of current economic growth to predict future economic growth at different horizons. In particular, we estimate the following panel-fixed effects set of regressions:

$$g_{i,t+h} = \alpha_{i,h} + \beta_h g_{i,t} + \varepsilon_{i,t+h}, \tag{6}$$

In equation (6), $\alpha_{i,h}$ represents country-specific fixed effects, which control for time-invariant unobserved heterogeneity. We repeat this prediction exercise across different horizons $h = 4, 5, 6$ and 7. In that way, we test the sensitivity of results across different horizons. We stop at $h = 7$ because, as mentioned in section 2, the historical average maturity of public debt in advanced economies has been around 7 years. We also rely on our sample which spans from 1870 to 2017, at annual frequency, for 18 advanced economies to estimate equation (6). This exercise allows us to explore whether, over the long-run, current economic growth contains information about the long-term economic growth g.

Table D1.1: Predicting future economic growth with current economic growth

	g_{t+4}	g_{t+5}	g_{t+6}	g_{t+7}
g_t	0.26***	0.20***	0.16***	0.16***
	(0.04)	(0.04)	(0.02)	(0.02)
Country FE	✓	✓	✓	✓
Observations	2335	2305	2275	2245

Notes: Sample period is 1870-2017, for 18 advanced economies. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D1.1 presents the corresponding coefficient point estimates and standard errors from our prediction exercise. Current economic growth is shown empirically to be a significant predictor of future real economic activity. Consequently, for our baseline exercise presented in equation (4) and shown in Figure 2, we construct $TB_{i,t(p)}$ for each country in the sample using current economic growth instead of the 7-year average annual future real GDP growth ($\bar{g}$) as we did in Section 2. This way, we capture the expected total public debt burden with the available information prior to the recession.

D.2 Yield spread to measure future economic growth g

In this appendix, we use an alternative measure of the long-term economic growth g to construct the variable $TB_{i,t}$ used in our empirical analyses. Our approach consists of two steps. First, we build on previous theoretical and empirical literature showing that the slope of the yield curve spread, defined as the difference between long-term and short-term government bond rates, can significantly predict future economic growth (Estrella and Hardouvelis, 1991; Plosser and Rouwenhorst, 1994; Estrella and Mishkin, 1997; Estrella, 2005; Duarte *et al.*, 2005; Bordo and Haubrich, 2008). We demonstrate that this empirical relationship holds for our long-run panel of 18 advanced economies. Second, for the empirical exercise presented in equation (4), we construct $TB_{i,t(p)}$ for each country in the sample using the yield spread instead of current real economic growth, as we did in Section 3. This way, we construct an alternative measure of the expected total public debt burden with the available information prior to the recession.

We start by testing the ability of the term spread to predict future economic growth at different horizons. In particular, we estimate the following panel-fixed effects set of regressions:

$$g_{i,t+h} = \alpha_{i,h} + \beta_h Yieldspread_{i,t} + \varepsilon_{i,t+h}, \tag{7}$$

In equation (7), $\alpha_{i,h}$ represents country-specific fixed effects, which control for time-invariant unobserved heterogeneity. We repeat this prediction exercise across different horizons $h = 4, 5, 6$ and 7. In that way, we test the sensitivity of results across different horizons. We stop at $h = 7$ because, as mentioned in section 2, the historical average maturity of public debt in advanced economies has been around 7 years. We also rely on our sample which spans from 1870 to 2017, at annual frequency, for 18 advanced economies to estimate equation (7). This exercise allows us to explore whether, over the long-run, the term spread contains information about the long-term economic growth g.

Table D2.1: Predicting future economic growth with the yield spread

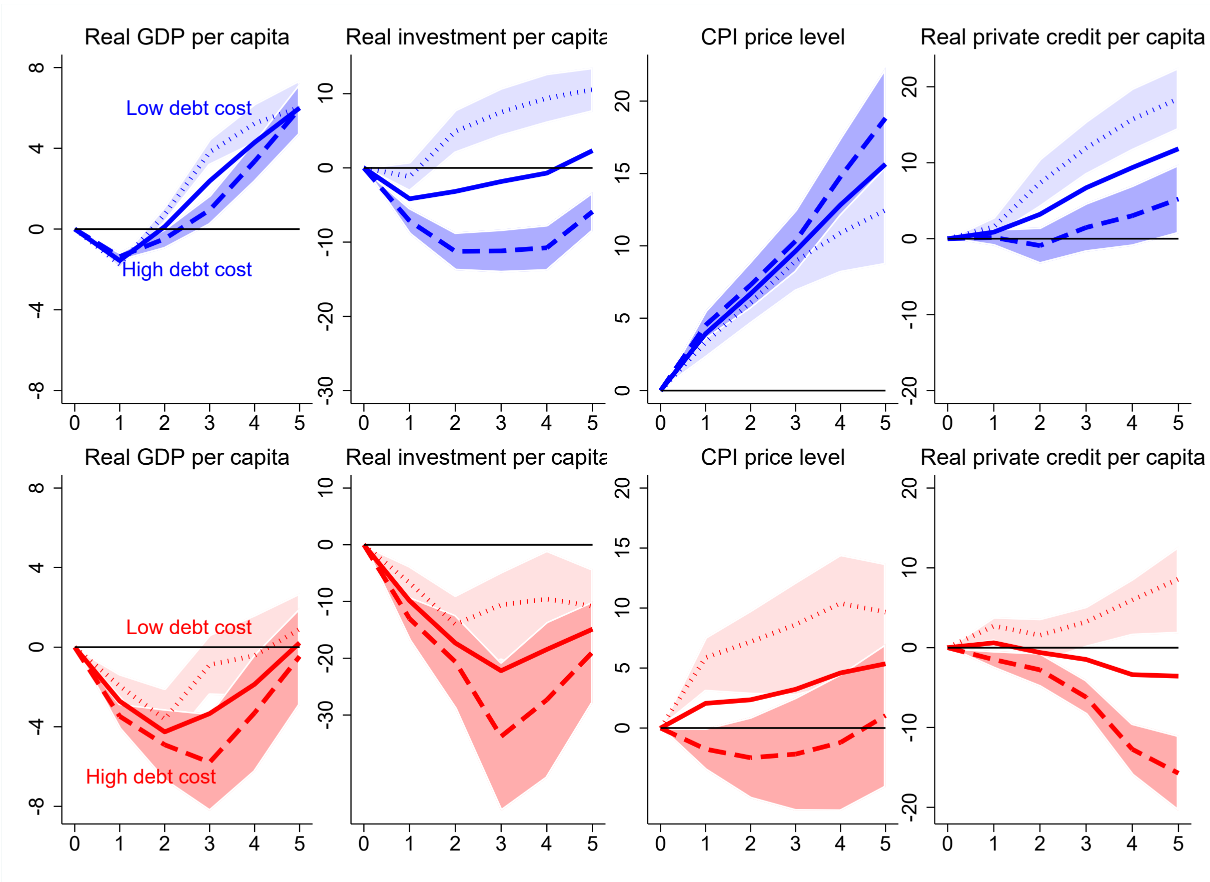
	g_{t+4}	g_{t+5}	g_{t+6}	g_{t+7}
$Yield\ Spread_t$	0.11**	0.15***	0.16***	0.19**
	(0.04)	(0.04)	(0.05)	(0.09)
Country FE	✓	✓	✓	✓
Observations	2265	2247	2229	2211

Notes: Sample period is 1870-2017, for 18 advanced economies. Robust standard errors in parenthesis. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table D2.1 presents the corresponding coefficient point estimates and standard errors from our prediction exercise. Our results are unambiguous. The slope of the yield curve is shown empirically to be a significant predictor of real economic activity. That is, the slope of the yield curve spread contains significant information about future economic activity.

For the empirical exercise presented in equation (4) and shown in Figure D2.1, we construct $TB_{i,t(p)}$ for each country in the sample using the yield spread instead of current economic growth, as we did in Section 3. This way, we capture the expected total public debt burden with the available information prior to the recession. The significant positive correlation between the term spread and future economic growth at different horizons implies that, all else equal, a higher term spread at time t implies a higher expected output growth in the future, and therefore a lower expected total public debt burden at time t.

Figure D2.1: Sensitivity Analysis: Crisis severity with the yield spread

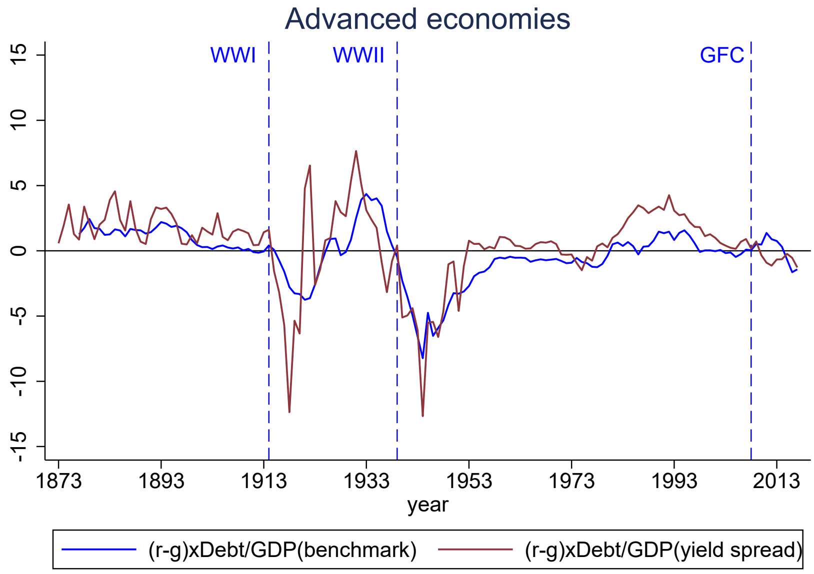


Notes: Average cumulative path from the start of the recession of selected macroeconomic variables, depending on the total cost of servicing the debt prior to the peak. Sample 1870-2017. Results are displayed by type of recession: normal versus financial crises. Each graph shows local projections of the cumulative change relative to peak for years 1–5 of the recession/recovery period under different scenarios. Three scenarios: (i) the country-specific initial total cost of servicing the debt is +1sd below its mean, *low debt cost scenario* (dotted line), (ii) the country-specific initial total cost of servicing the debt is at its mean (solid line), (iii) the country-specific initial total cost of servicing the debt +1sd above its mean, *high debt cost scenario* (dashed line). 68% confidence bands for high debt cost scenarios (dark red and blue) and low debt cost scenarios (light red and blue) are displayed. The top panel refers to normal recessions. The bottom panel refers to financial crisis recessions. These results are conditional on the full set of lagged macroeconomic aggregates, with paths evaluated at the means. Two world wars and 5 year windows around wars are excluded (1909-20; 1934-47).

To have an intuition about how the two proxies for the total cost of the debt compare over time, we also plot in Figure D2.2 the historical evolution of the total cost of the debt $TB_{i,t}$ using information into the future, i.e., based on the 7-year average annual future GDP growth ($\bar{g}$), against our proposed new measure using the available information at the peak, i.e., based on the yield spread. We plot these series for the average of all advanced economies in our sample. We refer to the former as our benchmark measure because, in the absence of endogeneity, we would use it to estimate the total cost of the debt at peak $t(p)$. The main takeaway from Figure

D2.2 is that overall, and despite some differences, the proxy for $TB_{i,t}$ computed using pre-crisis information behaves similarly to the benchmark measure. This reassures that our proposed proxy for $TB_{i,t(p)}$ does a good job capturing the total cost of the debt with the available information at the peak $t(p)$.

Figure D2.2: Historical Evolution of the total cost of the debt TB.



Notes: $TB = (r-g)\ x\ Debt/GDP$. We plot two measures: the benchmark measure, where $(r-g)$ has been constructed using the 7-year average annual growth rate of future real GDP (as explained in section 2) and our proposed measure for the empirical analysis, where $(r-g)$ has been constructing using the yield spread. For all advances economies, we use the average historical mean across countries.

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