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# Managing government debt at high altitude: velocity, instability and headwinds

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# Managing government debt at high altitude: velocity, instability and headwinds

Sebastian Barnes, Eddie Casey and Elliott Jordan-Doak[1]

March, 2021

## Abstract

The Global Financial Crisis and Covid-19 pandemic have led to governments accumulating record levels of debt. Reflecting secular declines and unprecedented monetary support, interest rates have fallen dramatically. This has seen interest-growth rate differentials largely turn negative, likely meaning they will remain favourable for debt reduction for some time. We explore the theoretical debt dynamics associated with these conditions and some empirical considerations for Ireland and selected OECD economies. We make three arguments. First, high debt ratios and favourable interest-growth differentials provide fiscal space for governments to run higher primary deficits and should allow for a fast speed of debt reduction. Second, higher debt ratios are inherently unstable: increasing vulnerabilities to interest-growth rate reversals with higher levels of debt. Third, ageing populations mean strong headwinds for the public finances as spending on pensions and healthcare rises and as workforces shrink, hence reducing growth and revenues. These headwinds will tend to expand deficits and push debt ratios higher.

Keywords: Fiscal Policy, Debt Sustainability Analysis

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## Introduction

The level of government debt-to-national income in advanced economies is set to reach its highest level in peacetime. This follows the Global Financial Crisis (GFC) and the Covid-19 pandemic. It comes against a background of rising fiscal indebtedness in most countries since the 1970s. Government debt ratios are typically around 100 per cent of national income, up from below 60 per cent prior to the GFC.

At the same time, interest rates on government borrowing have continued a trend decline of past decades to reach historically unprecedented lows with yields around zero or even negative in many cases. Given that economies are expected to continue to grow, the interest-growth differential is materially negative for many advanced countries. Markets imply that interest rates will remain very low for many years to come.

Taken together, this constitutes a new "high-altitude" public debt regime. As with aircraft flying at high altitude, the low interest rates and the negative growth differential have created very favourable dynamics for public debt. This eases the limits on the sustainable level of debt or the primary balance. However, the higher level of debt increases sensitivity to interest rates and growth, so increases the risk of instability.

This paper explores three aspects of the high-altitude public debt regime. First, it considers in quantitative terms the improvement in debt dynamics and the consequent increase in the debt limit for a given primary balance and interest-growth differential. It provides estimates of the improvement in debt dynamics for OECD economies since the Covid-19 pandemic. Despite the increase in debt, lower interest rates and the—counterintuitive—downwards effect that higher debt ratios exert when the interest-growth differential is negative have improved dynamics.

Second, it considers the stability of the government debt ratio path in the high-altitude debt regime. Higher debt ratios increase the sensitivity to changes in interest rates and growth in proportion to the debt level. The interest-growth differential is unpredictable and volatile. While increased maturity on government debt provides some protection against interest reversals in the years ahead, there is little protection against uncertainty on nominal growth. The debt ratio could climb again due to new shocks or recessions. Positive feedback between debt levels and interest rates would add to the risks of debt reaching a point of instability.

This paper argues that a further channel adds to the risks — the speed of adjustment of fiscal policy in response to a change in circumstances is constrained by political economy and economic factors. A higher debt ratio would require a larger change in the primary balance for a given deterioration in economic fundamentals. These factors are exacerbated in a low-nominal growth environment, where fiscal adjustments have to be made in the form of explicit nominal spending cuts or tax increases rather than in the form of "stealth" adjustments through slower-than-inflation nominal changes. The tightening of this constraint at low growth rates may add to the sensitivity of the public finances to growth.

Third, there is an important headwind in the form of demographic ageing. Pensions costs are already far higher than interest costs in advanced economies and payments are set to rise more rapidly than the economy grows in the coming decades. This would—in the absence of policy changes—lead primary balances to deteriorate significantly in the years ahead, tending to worsen debt dynamics to the point where they may be insufficient to stabilise the debt ratio. In effect, pensions liabilities are being accumulated both in line with wages through indexation of entitlements and as a result of the growing number of pensioners due to rising life expectancy and the retirement of baby boomers. The paper quantifies these effects for EU countries based on projections from the EU Ageing Working Group.

This paper contributes to the recent literature on the implications of low interest rates, and below the rate of growth, for the public finances and fiscal policy more fundamentally going forward. While likely accelerated by the Covid-19 crisis, researchers have argued that the current environment is structural, and one in which a "major rethinking of macroeconomic and fiscal policy is in order" (Blanchard and Summers, 2019).

Blanchard (2019) sets out the underlying economics of this situation in terms of the dynamic efficiency of the economy. He argues while the appropriate level of debt is unclear, both the associated fiscal and welfare costs in the current environment may be lower than previously thought. Similarly, Furman and Summers (2020) argue that if low real interest rates are a function of output sitting lower than potential, further fiscal expansion is warranted to boost growth and foster financial stability. Blanchard, Leandro and Zettlemeyer (2020) proceed to develop the implications in the context of the EU fiscal rules, noting that capital budgeting and fiscal standards could better reflect these dynamics in intertemporal fiscal frameworks.

While low real rates mechanically increase the fiscal space for governments, the policy implications of these dynamics have been contested. Rogoff (2020) highlights that despite the case for accelerated investment spending and other uses, government liabilities are actually far higher than captured in the standard debt-to-GDP metric when including off-balance sheet liabilities. This includes pension liabilities and other contingent liabilities that may arise, such as private debt likely to become part of the government's balance sheet in a crisis. These additional commitments increase both the sovereign risk profile and the welfare costs of debt overhangs (Reinhart et al., 2012). This point is particularly important in the context of Covid-19, where many states have accumulated greater implicit and explicit liabilities over the course of the crisis. Additionally, fiscal policy is inherently constrained by political economy factors, restricting its ability to be used in the same technocratic fashion as monetary policy.

In a similar vein, Wyplosz (2019) notes that the favourable dynamics in today's sovereign debt markets are unusual and prone to rapid and powerful reversals. In line with Alesina and Tabellini (1990), and Yared (2019), he argues that they may contribute to governments accumulating greater stocks of debt. These arguments on the macro-financial risks associated with higher debt levels in a low interest rate environment are echoed by Mauro and Zhou (2020) and Badia et al. (2020). Bohn (2010) ties these factors together to note that a state's capacity to access liquidity should not be overused, and that with rising debt and liabilities comes, all else equal, greater doubts about the solvency of a government and the stability of monetary policy.

Taken together, the analysis in this paper suggests that the additional fiscal space created by favourable debt dynamics should be used cautiously, given the heightened risks at high altitudes of debt and ageing headwinds. While governments should benefit from swift declines in debt ratios initially, a credible medium-term plan for fiscal policy that anchors the debt ratio and allows space for adjustment if conditions deteriorate would be prudent.

Section 1 assesses the implications of a favourable interest-growth differential for debt dynamics and maximum sustainable debt ratios, including the impact of post-Covid-19 changes. Section 2 considers the uncertainty around this path and implications of a higher initial debt ratio. Section 3 looks at the impact on the public finances of population ageing and pensions costs. Section 4 concludes.

# 1. Velocity: favourable dynamics of high debt and i<g

The government debt-to-income ratio provides a measure of the capacity to support the debt through the state's ability to tax. The dynamics of the debt ratio depend on the level of debt, the nominal interest rate, nominal growth and primary balance with positive interest rates tending to increase the ratio, while positive growth or a primary balance tend to reduce it. This can be summarised using the well-known debt "snowball" equation:

$$\Delta D_t = D_{t-1}\frac{i_t - g_t}{1+g_t} - PB_t + SF_t \quad (1)$$

where $D_t$ is the debt-to-output ratio, $i_t$ is the average effective interest rate, $g_t$ is the nominal output growth rate, $PB_t$ the non-interest or "primary" budget balance-to-output ratio, and $SF_t$ the stock flow adjustment.[2] [3]

### Debt dynamics

If the interest rate is lower than the growth rate, the debt dynamics are favourable in the sense that the downward force on the debt ratio from growth is greater than the upward pressure from interest costs. Debt ratios will fall in cases where the primary balance is greater than the "snowball" term:

$$\Delta D_t \leq 0 \text{ if } PB_t \geq D_{t-1}\left(\frac{i_t - g_t}{1+g_t}\right) \quad (2)$$

Counterintuitively, the downward effect when i < g is larger when the debt ratio is higher. This is shown in Equation (2), with the debt ratio term $D_{t-1}$ magnifying the i-g term. Debt dynamics will therefore be more favourable initially, albeit from a higher level. That is, it is easier for governments with higher debt to achieve a faster pace of reductions in the debt-GDP ratio or, equivalently, a larger primary deficit is consistent with a stable debt ratio. This is the opposite of the situation where i > g, where, more intuitively, higher debt leads to more challenging debt dynamics. As

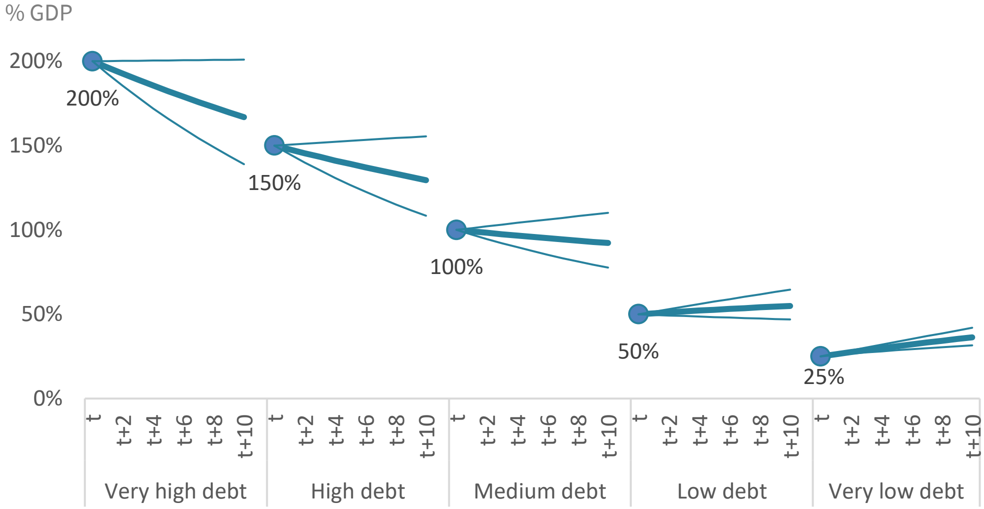
[2] The average effective interest rate is given by general government interest costs expressed as a share of the previous period's nominal debt level. The primary balance is expressed as a share of nominal output.

[3] The stock-flow adjustment reflects factors such as changes in cash balances, bank recapitalisations or other adjustments to the debt ratio not captured by other terms.

discussed in the next section, this counterintuitive feature reduces as the debt ratio falls and higher debt also makes the debt dynamics more uncertain.

Figure 1 illustrates this counterintuitive result. We show scenarios where debt ratios start at different levels ranging from very high debt ratios of 200 per cent of GDP to very low levels of 25 per cent of GDP. For a central assumption, we set i<g by 3 percentage points (or i-g = -3 per cent), consistent with nominal growth of 4 per cent and interest rates at 1 per cent. The primary balance is set as a 2 per cent of GDP primary deficit — about what would be consistent with a 3 per cent of GDP overall deficit.[4]

## Figure 1 How high debt benefits more from i<g




Sources: Own workings.
Notes: For different starting debt ratios, the figure shows how illustrative cases of i<g help higher debt ratios to fall quickly. The central lines assume i-g = -3%, where i<g helps higher debt ratios to fall quickly. For the outer lines, i-g = -1% and -5%. We assume primary deficits of 2%.

With these favourable dynamics, starting with a high debt ratio of 200 per cent of GDP, debt would fall by 33 percentage points to 167 per cent of GDP over a 10-year period. This reflects how the positive i-g "snowball" effect far outweighs the negative impact from the primary budget deficit. Starting from a debt ratio of 100 per cent, the ratio would fall by 8 percentage points over a decade. The benefits of these more favourable dynamics, where debt ratios are high and i<g, fade as the debt ratio falls. For a country with a very low debt ratio of 25 per cent of GDP, the debt ratio would rise over the decade to 36 per cent. This reflects the i-g dynamics

[4] This is broadly consistent with a 3 per cent of GDP deficit if the effective interest rate is assumed to be one per cent and the debt ratio is 100 per cent of GDP.

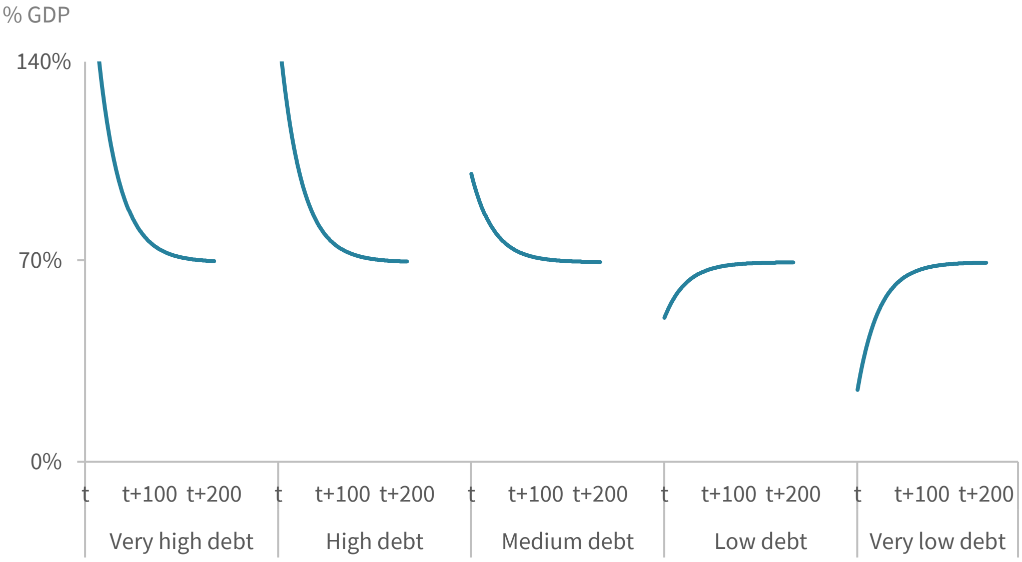
assumed coupled with the impact of the primary deficits being run, which cause debt to rise for a time before the debt ratio eventually stabilises. As we show, unless i-g reverses and turns positive—so that i>g—the favourable effects remain.

### Steady state

In an i<g world, debt will ultimately converge over the very long run to a stable debt ratio. This happens from each configuration of the main drivers, irrespective of what the starting debt ratio is. We can show this tendency towards a given debt ratio over the very long run if we assume different starting points for the debt ratio, but identical primary deficits and i<g configurations. For example, using the same assumptions as above, Figure 2 shows that maintaining a primary deficit of 2 per cent of GDP over the long run, with i-g at -3 per cent will ultimately lead to steady state debt ratios of about 70 per cent of GDP.

This analysis also shows that countries with high debt ratios could remain far from the steady state and continue to benefit from the favourable dynamics—if conditions do not change—for many decades. Again, this transitional period will last longer for countries starting from higher debt ratios.

## Figure 2: Eventually dynamics give way to steady-state debt ratios




Sources: Own workings.
Notes: For different starting debt ratios, the figure shows how an illustrative case of i<g of i-g = -3% initially helps higher debt ratios fall quickly before all paths lead to the same long-run debt ratio. Here, we assume a primary deficit of 2%.

### Debt limits

The i<g world implies debt ratios will ultimately stabilise. In the very long-run, the steady state debt ratios reached depend on the extent to which i<g and the primary balance being run. Larger primary deficits mean larger—but ultimately stable—debt ratios. A less negative i-g value means larger debt ratios. In the i<g world, any primary deficit is consistent with a stable debt ratio. Any primary surplus (or a primary balance of zero per cent of GDP) will ultimately erode debt when i<g, because the steady state level of the debt ratio will be under these conditions, either zero or negative. Table 1 shows this for a variety of configurations.

## Table 1: Debt ratios will converge in the long run, regardless of starting points, for given primary balances and i<g levels

Debt ratios converged to over the long run, % GDP

| | | i-g | | | | | |
|---|---|---|---|---|---|---|---|
| | | -6 | -5 | -4 | -3 | -2 | -1 |
| Primary balance | 3 | <0 | <0 | <0 | <0 | <0 | <0 |
| | 2 | <0 | <0 | <0 | <0 | <0 | <0 |
| | 1 | <0 | <0 | <0 | <0 | <0 | <0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | -1 | 17 | 21 | 26 | 34 | 52 | 103 |
| | -2 | 34 | 41 | 52 | 69 | 103 | 206 |
| | -3 | 52 | 62 | 77 | 103 | 155 | 309 |
| | -4 | 69 | 82 | 103 | 137 | 206 | 412 |
| | -5 | 86 | 103 | 129 | 172 | 257 | 515 |

Sources: Own workings.
Notes: The table shows the debt ratios that are converged on over the very long run for a variety of i<g configurations in percentage points and primary balances as % GDP. We assess for over two millennia, though, in a substantive sense, convergence is typically achieved in a century. The exercise assumes that g = 3%. Other assumptions for realistic values of g do not produce substantially different outcomes.

While the government can run any primary budget deficit (spend more on services and transfers than it raises in taxation) indefinitely while maintaining a stable debt ratio,[5] the altitude at which debt ratios eventually stabilise can be very high depending on i-g and the primary deficit being run.

[5] This assumes no stock-flow adjustments.

A question to ask is what happens if i-g dynamics reverse for a given primary balance? While, mathematically, there is no definable point at which the debt ratio becomes explosive in an i<g world, there is such a limit in an i>g world. That is, in the i>g world, if we assume that there is a practical limit to the size of the primary surplus a government can sustain indefinitely, then we can derive a theoretical limit for debt ratios. These limits might arise due to social or political reasons.

As noted in Blanchard (1984), a maximum primary balance is a fuzzy concept and difficult to assess in practice. It will inevitably vary by country and over time. But a limit for how large a primary surplus can be run can be thought of as depending on things like:

- the maximum amount of taxes that can be collected by the government (this could be in terms of what is politically attainable or in terms of limits on collection before behavioural changes cause less taxes to be raised);
- the minimum socially acceptable amount of government spending;
- timing factors (e.g., the need to do things more quickly than is logistically possible); and
- the political system or government composition (e.g., is it a coalition or a large majority that can easily enact larger primary surpluses).

Assuming that there is some maximum primary balance, then, in an i>g world, adjusting Equation (1) gives us the maximum steady-state debt ratio $D^{max}$ for a given maximum primary balance. This $PB^{max}$ is the largest primary balance that can hypothetically be run for any sustained period. If the associated debt limit $D^{max}$ is exceeded, then the level of debt will be forever increasing:

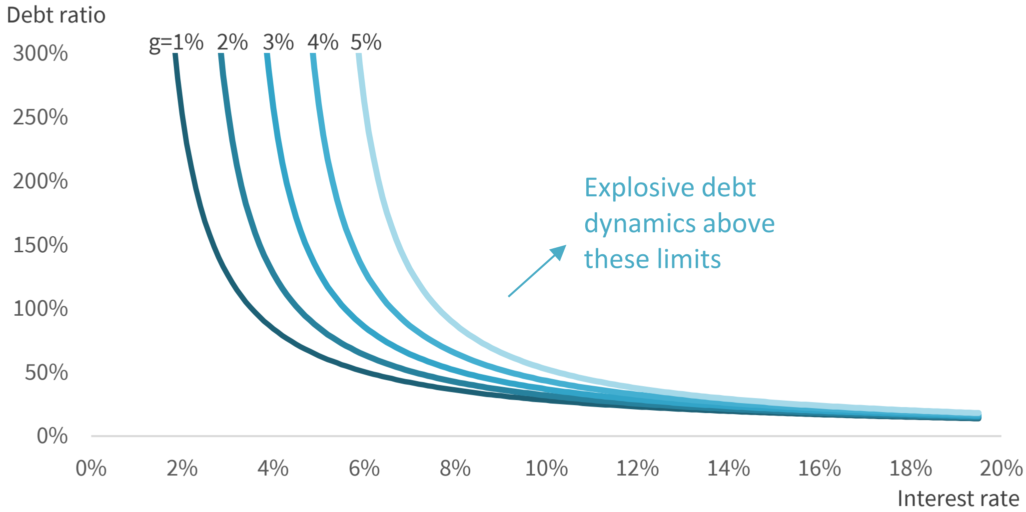
$$D^{max} = PB^{max} / \left(\frac{i-g}{1+g}\right) \tag{3}$$

This debt ratio limit increases as the interest-growth differential becomes more negative for a given primary balance. Figure 3 shows the debt limits (the maximum sustainable levels of debt ratios) for assumed maximum primary surpluses of 2.5 per cent.[6] For a given interest rate, the limit is higher for higher rates of growth. The

[6] This is equivalent to the 80th percentile of all of the primary balances run by the 12 countries considered in Figure 6 over the last century.

relationships are non-linear in the region of debt ratios from 50 to 100 per cent of GDP and interest rates between around 2.5 per cent and 7.5 per cent. At relatively high interest rates, limits are low and do not vary much with growth. At low interest rates, the limits shift significantly with a change in growth but in largely proportional way. As we show in the Annex, the larger the primary balance that can be run, the more the debt limits shift outwards while retaining their general shape.[7]

## Figure 3: Debt limits for different growth and interest rates




Sources: Own workings.
Notes: For an assumption that primary balances beyond +2.5% cannot be sustainably achieved, the chart shows corresponding debt ratio limits. That is, levels, where if debt exceeds these, debt will be forever increasing.

### Debt dynamics post-Covid 19

Applying the logic of debt dynamics to selected OECD countries following the Covid-19 shock, a noticeable improvement can be seen in the debt dynamics, owing to interest rate falls consistent with a more favourable i-g dynamic, despite the sharp increase in debt since the crisis.

The debt stabilising primary balance—the primary balance that would keep debt ratios constant at their current level—can be split into two components or contributions as in Equation (4). The first term can be thought of as the contribution

[7] For maximum primary balances closer to zero, the limits approach vertical lines where much lower limits—lower than 10 per cent of GDP—apply when i>g.

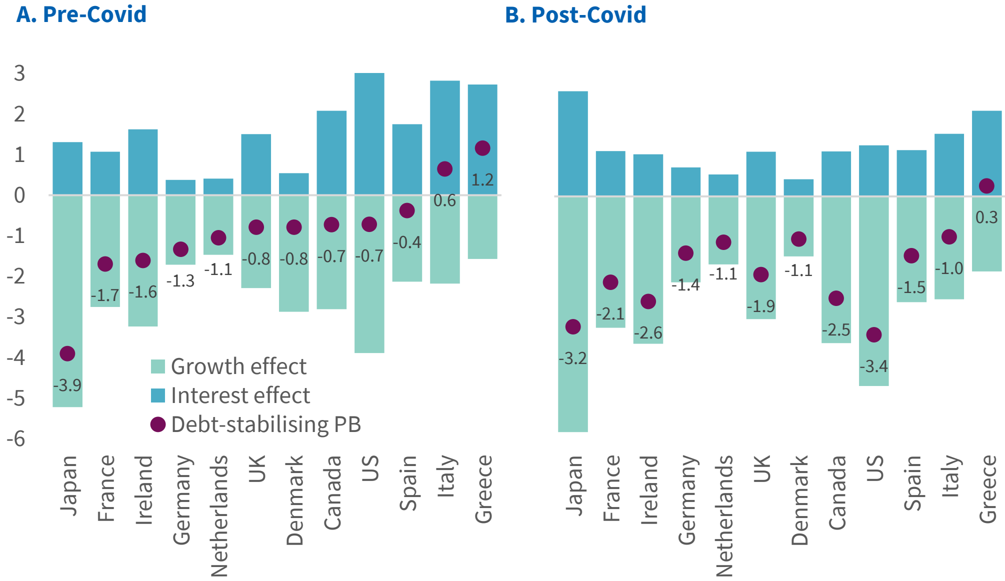
from average effective interest rates on debt; the second term can be thought of as the growth contribution:

$$PB_t^{debt-stabilising} = D_{t-1}\left(\frac{i_t}{1+g_t}\right) - D_{t-1}\left(\frac{g_t}{1+g_t}\right) \quad (4)$$

Figure 4 compares the post-Covid-19 debt-stabilising primary balances to the pre-Covid 19 situation given the upwards shift in debt and the fall in interest rates. Both figures are ordered by the pre-covid numbers. With Japan the only exception, the debt-stabilising primary deficit is larger in the post-Covid-19 era, by up to 2.7 per cent of GDP. The improvement in the debt-stabilising primary deficit is typically in the range of 0.3 to 1.1 percentage points, although it implies a debt-ratio that is typically some 12 to 23 percentage points higher in most countries than prior to the Covid-19 crisis.

## Figure 4: Favourable Debt Dynamics Post Covid-19

% GDP (GNI* for Ireland)




Sources: OECD, IMF, and Fiscal Council workings.

Notes: Blue bars denote interest rate effects in the debt dynamics equation, green bars denote growth effects, and point estimates indicate the primary balances at which debt stabilises. This exercise employs potential output growth rates from the OECD's December 2020 Economic Outlook for all countries.

This reflects several effects. First, the higher debt ratio has magnified the impact of the favourable debt dynamics already prevailing prior to the Covid crisis. Second, there has been a significant further fall in interest rates. This exercise assumes that interest rates converge to 1 per cent (well-above their post-Covid levels) and that medium-term growth rates have not been affected by the pandemic.[8] Taken together, both effects contribute to decrease the required debt-stabilising primary balance.[9] It is also important to note that this exercise highlights the impact of favourable i<g dynamics at high debt levels. While the fall in interest rates will have led to more negative i<g levels, and hence more favourable dynamics that allow for greater fiscal manoeuvrability, debt levels remain considerably elevated.

From a policy perspective, the debt dynamics could be further improved by public investment programmes that can be shown to increase the rate of growth. This would mostly operate through an expansion of the denominator of the debt ratio through an increase in the growth rate while the capital stock reaches a new steady-state level.[10] The gains from this approach in terms of the improvement of debt dynamics are higher when the starting debt ratio is higher. Naturally, this speaks to a broader endogeneity between policy, economic growth, the public finances, and the interest rate at which the government pays to borrow. These dynamics have yet to be fully explored in the current "high altitude" regime, therefore for the purposes of the exercises in this paper we do not address this question directly.

[8] We use nominal medium-term trend growth rates in this exercise—assuming these are the same in both scenarios—to account for the volatility and uncertainty of growth in 2020 and 2021.

[9] The only exception to this in our sample is Japan, where implied interest rates on government debt were around 0.5 per cent prior to the Covid-19 crisis. In this exercise we assume interest rates converge to 1 per cent, which serves to tighten the budget constraint for Japan post-Covid-19.

[10] While it would increase the primary balance in absolute terms, there is no specific reason why it would raise the primary balance relative to GDP.

## 2. Instability and uncertainty at high levels of debt

While high debt improves debt dynamics when i < g, it increases uncertainty about debt and debt dynamics because sensitivity to the key parameters increases.

First, the sensitivity of changes in the debt ratio to interest rates or growth is largely a linear function of the initial debt ratio. For example, we can differentiate the debt ratio ($D$) with respect to interest rates ($i$) to get:

$$\frac{d(D)}{d(i)} = \frac{D}{1+g} \tag{5}$$

A one percentage point increase in interest rates would alter the trajectory of the debt ratio by 0.6 percentage points of GDP if the debt ratio is 60 per cent, but by 1.2 percentage points if the initial debt ratio is 120 per cent. To maintain the same trajectory for the debt ratio would therefore require correspondingly larger changes in the primary balance.

The sensitivity of changes in the debt ratio to growth is given by:

$$\frac{d(D)}{d(g)} = -D\frac{(1+i)}{(1+g)^2} \tag{6}$$

We can see from this equation that increases in growth rates have a broadly linear relationship with changes in the debt ratio also. Albeit that there is some gradually diminishing impact at larger growth rates.[11]

At higher levels of debt, such as at a debt ratio of 120 per cent, a one percentage point increase in growth rates from a starting growth rate of zero per cent will alter the debt ratio’s trajectory by 1.2 percentage points, whereas an increase in growth rates from a starting growth rate of ten per cent will alter it by 1 percentage point.

Second, this implies that an increase in interest rates or a shortfall in growth would increase the steady-state debt ratio for a given primary balance, potentially

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[11] For example, a one percentage point increase in growth rates where growth is initially zero will alter the debt ratio’s trajectory by 0.6 percentage points of GDP if the debt ratio is 60 per cent, whereas a one percentage point increase in growth rates will alter it by 0.5 percentage points if the growth rate is already ten per cent.

implying a very high level of debt that could be unfeasible for reasons outside this simple framework such as the willingness of investors to buy government debt. Moreover, a sufficient increase in interest rates or deterioration in growth could reverse the sign of the interest-growth differential and create unfavourable dynamics. This would introduce a binding maximum debt level consistent with a given primary balance and potentially require fiscal adjustment to maintain a stable debt path.

Third, historical relationships suggest that there can be limited confidence in the interest-growth differential remaining so favourable, with high variation observable over time.

Market-implied rates suggest that interest rates across the global economy are set to be low for some time to come. This indication is consistent with a swathe of research arguing that today's low-interest-rate environments is a function of longer-term structural pressures on interest rates in advanced economies. Relatively older working age populations with high savings (Lunsford and West, 2018), income inequality (Straub, 2017; Auclert and Rognlie, 2016), adverse trends in productivity growth that meant a dearth of attractive investment opportunities (Eichengreen, 2015), safe asset shortages (Caballero, Farhi, Gourinchas, 2017) and arguments of broader secular stagnation (e.g. Summers, 2015; Rachel and Summers, 2019) are thought to have contributed to the falls seen in interest rates.

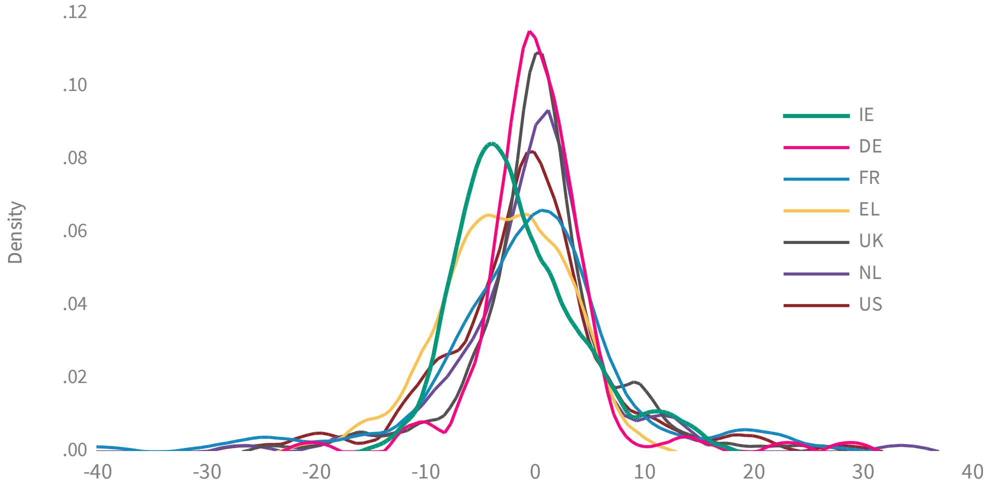
However, these effects may not last forever and there is significant uncertainty around whether the current low levels can indeed be sustainably attributed to those factors. For example, productivity growth rates are prone to discrete changes and the recent slowdown could be due to novel circumstances (Crafts and Mills, 2019). This does not rule out the possibility that rates could rise significantly, even if they were to remain below levels seen in recent decades.

Similarly, on output growth, a well-documented optimism bias may also raise questions about assessments of future growth prospects. This is the result of common assumptions such as economic growth converging to its potential growth rates or feedback effects of fiscal consolidation being underplayed (Guzman and Heymann, 2015).

In terms of the differential between interest rates and growth, Figure 5 highlights the variability in this relationship. It shows the distribution of annual interest-growth rate differential outturns for seven of the twelve countries we consider over two centuries of data (Figure B shows all countries considered separately). Distributions are typically peaked, with more observations close to a primary balance than in a normal distribution. There are also fat tails — more observations at extreme levels than would be predicted by a normal distribution. There is also typically some skewness to the distributions, albeit in different directions.

## Figure 5: Interest growth rate differentials are wide-ranging

Interest-growth rate (r-g) differentials in percentage points



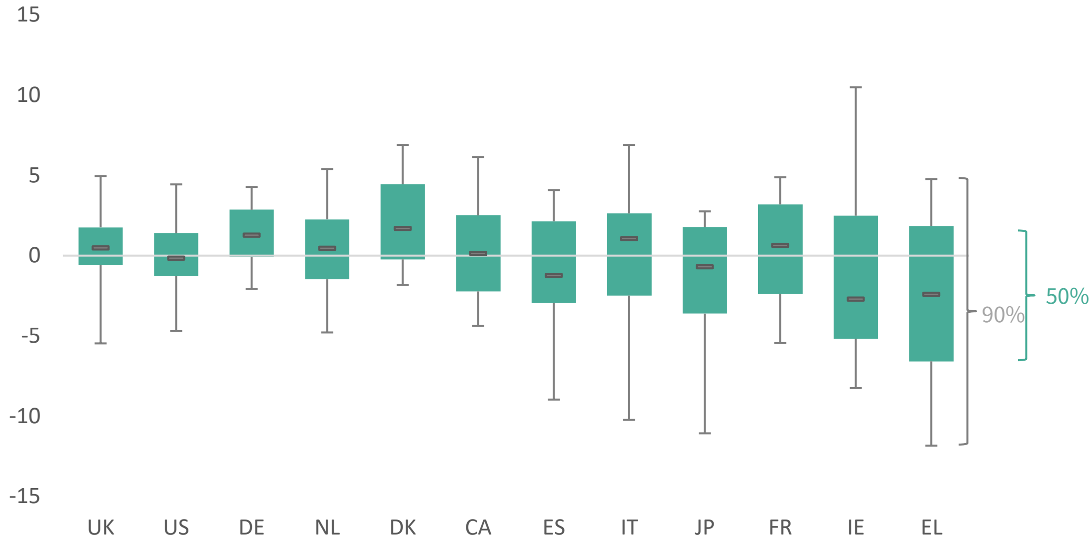

Sources: IMF ModHist (Mauro et al 2013); own workings.
Notes: The chart shows the distribution of r-g values for the G7 + Ireland, Spain, Greece, Netherlands, and Denmark, where real growth and interest rates are used. The sample period varies but runs to 2011, with earliest observations: UK 1831, FR/DE/US/NL 1881, EL 1961, and IE 1964.

In addition, some countries have had far wider ranges for interest-growth differentials than others historically. For instance, the interquartile range for Ireland and Greece is about three times wider than that of the US, UK and Germany.[12] For France, Japan, Italy and Spain, it is about twice as wide.

[12] See Box H, Irish Fiscal Advisory Council (2017), for a broader discussion of the implications of this for Ireland in particular.

## Figure 6: Some countries have much wider ranges than others

Interest-growth rate (r-g) differentials in percentage points




Sources: IMF ModHist (Mauro et al 2013); own workings.

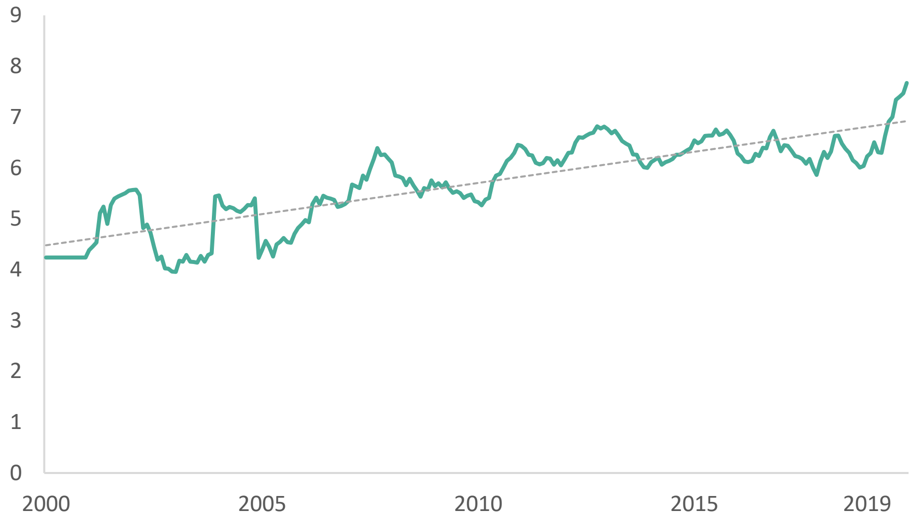
Notes: The chart shows the distribution of r-g values for the G7 + Ireland, Spain, Greece, Netherlands, and Denmark for a common sample period of 1966–2011.The middle line shows the median value, the bars show the interquartile range (the middle 50% of outturns), the whiskers show the 5th percentile and 95th percentile, respectively starting from the bottom (the range of which captures 90% of outturns).

There are also questions about the sustainability of such large interest-growth differentials. Ireland's own experiences suggest that persistently low interest rates relative to growth leaves the economy prone to instability and pressures on the financial system, particularly through the housing market and credit channels. Along these lines, and using confidential US bank data over 1997 to 2011, Dell'Ariccia, Laeven and Suarez (2017) show that banks take greater lending risks when short-term interest rates are low. This chimes with the literature (for example, Borio and Zhu, 2008) on shifts to riskier assets and higher leveraging as investors reach for yield when interest rates are lower.

At present, lengthening debt maturities suggests that governments are reducing the risk associated with interest rate reversals. Indeed, sovereign issuers with investment grade debt have managed to lengthen the average maturity of their issuance over the period from 2000 to 2019 by about 3½ years, from 4.2 years to 7.7 years (Figure 7). While structurally low rates coupled with prudent debt management by states reduces interest rate risk somewhat, it is more difficult for policymakers to insure against shocks to growth. On the other hand, maturity conditions have been more volatile for non-investment grade issuers and have somewhat deteriorated over the same period.

## Figure 7: Governments have lengthened debt maturities

Average value-weighted maturity in years, rolling 12 months




Source: 2020 edition of the OECD Sovereign Borrowing Outlook.
Notes: Data are for investment grade sovereign issuers and are based on OECD calculations using data from Refinitiv.

Fourth, if the interest-growth differential were to become less favourable, there is a risk that solvency concerns would feedback into higher interest rates, creating a positive feedback loop where more concerns about solvency lead to higher interest rates and thereby further undermine solvency. Such multiple equilibria and endogeneity are outlined by Blanchard (2019) in the context of the current environment, and well documented by others in a wide range of other frameworks (e.g., Lorenzoni and Werning, 2019; McMahon, 2017; Bohn, 1995; Rogoff, 1990; Calvo, 1988). These dynamics are likely to be amplified by factors such as high levels of private debt and stretched asset price valuations.  While the former has important implications for solvency of businesses in the real economy, the latter could lead to greater financial market volatility when a shock arrives.

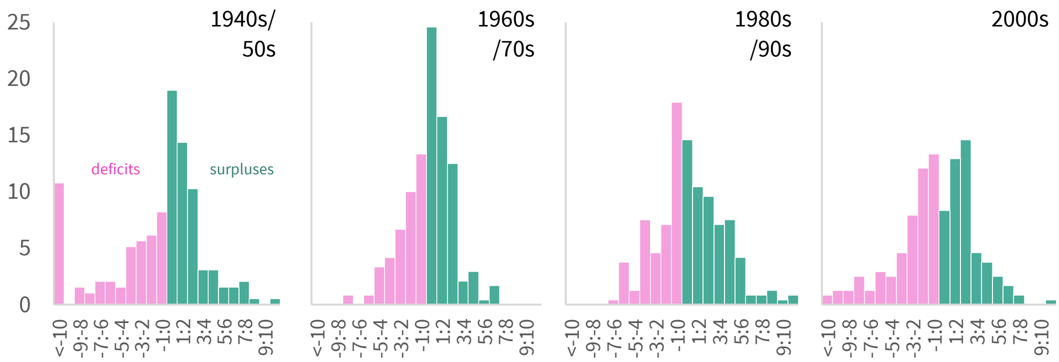
Fifth, as noted in Equation (4), increases in the debt ratios often come from upwards shifts rather than the accumulation of interest, growth and primary balance differentials. This can arise either as the result of a recession or financial crises that lead the State to take on additional liabilities quite suddenly. This suggests that risks of a sharp increase in debt are higher than those simply suggested by projecting forward the current debt dynamics.

Sixth, a shift to less favourable debt dynamics would require a larger primary balance to maintain the same trajectory for the debt ratio, more so for higher debt levels. A sufficiently large deterioration in the debt dynamics would require maintaining larger outright primary budget surpluses. Yet maintaining large primary surpluses may be challenging, as noted above and discussed in greater detail below.

We can see that, historically, large primary surpluses have not been very common. For instance, there is typically a large falloff in the incidence of annual primary surpluses above 2-3 per cent (Figure 8). This is more noticeable in the 2000s with less than 14 per cent of all primary balances run annually being greater than 3 per cent.

## Figure 8: Larger primary surpluses are uncommon

Observed primary balances, % observations by bins, 1940–2020

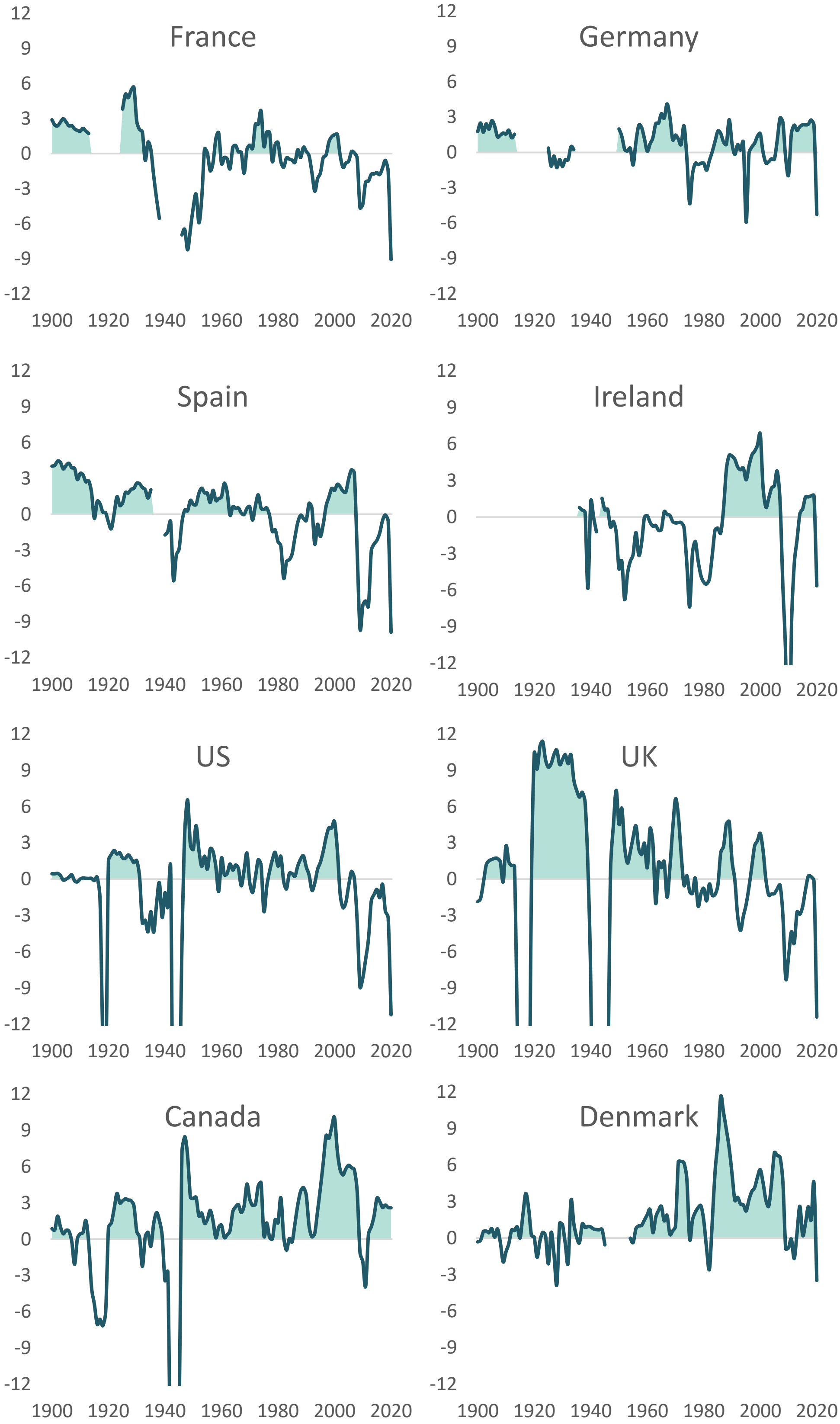



Sources: IMF ModHist (Mauro et al 2013); AMECO; and own workings.
Notes: We pool the data from each of the twelve countries we consider (G7 countries + IE, DK, NL, EL and ES) for the periods 1940-1959; 1960-1979; 1980-1999; and 2000-2019.

We can also see that episodes where large primary surpluses are run for a prolonged period are relatively rare (Figure 9). In the past four decades and among the twelve countries we consider, for example, there are just 14 episodes where countries managed to run primary surpluses larger than 2.5 per cent of GDP for longer than two years. Half of these episodes were accounted for by Canada, the UK and Denmark. Canada is a particular exception having managed to run large primary surpluses through the 1990s and early 2000s. Yet this was only following major restructurings of spending, including reforms to unemployment benefits and pensions (Mauro, 2011). Other countries only managed one episode of running a greater-than-2.5 per cent primary surplus for more than two years across the four decades, while France and Germany never managed it.

## Figure 9: Large surpluses are typically not sustained either

Primary balances % GDP

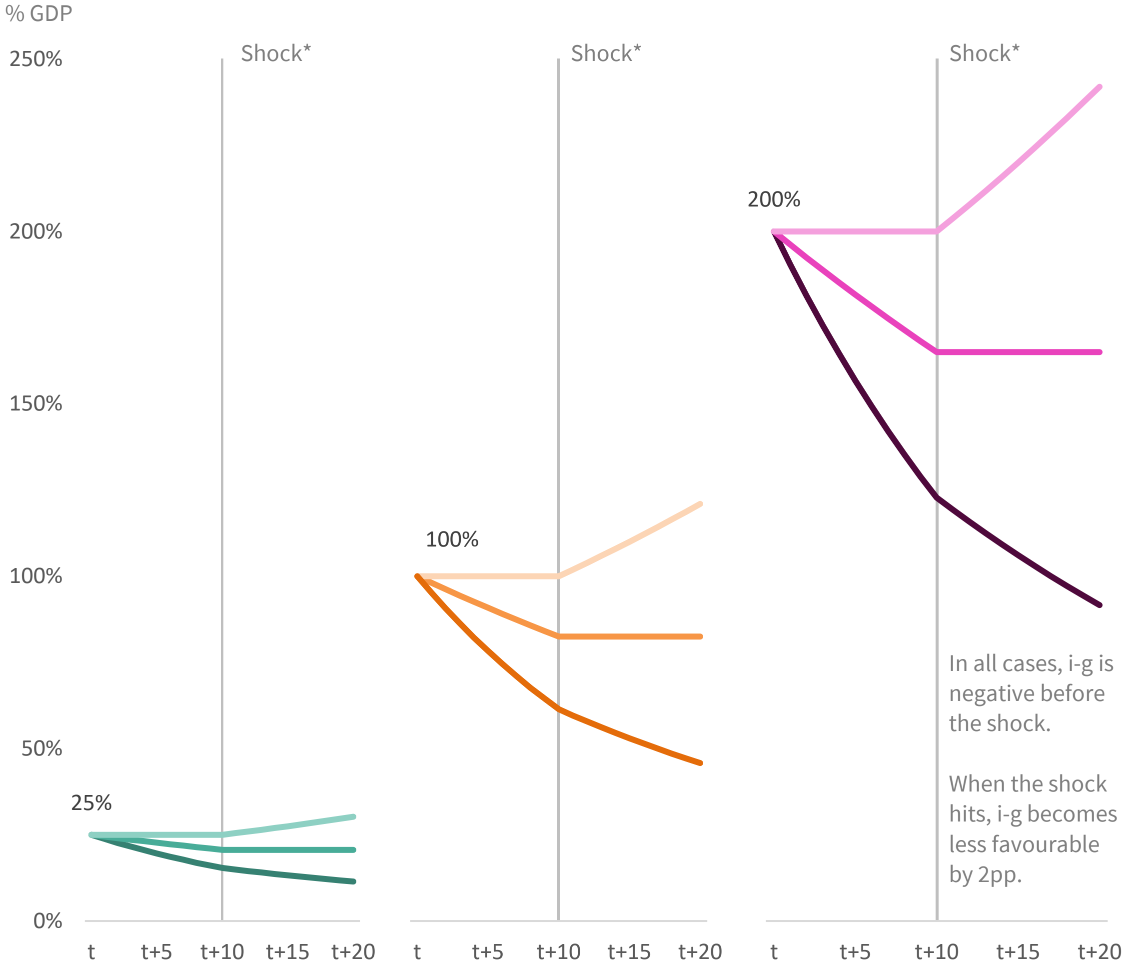



Sources: IMF ModHist (Mauro et al 2013); AMECO; and own workings.

**What happens if unfavourable shocks hit?**

To explore the implications of these uncertainties, we examine a range of scenarios where a shock to i-g occurs.

## Figure 10: Shocks are amplified at higher levels of debt




Sources: Own workings.
Notes: For different starting debt ratios, the figure shows how debt ratios evolve for an illustrative i-g of -5% (darkest lines), -2%, and 0% (lightest lines) and a primary balance = 0. * The shock shows what happens if the i-g differential worsens by 2 percentage points.

Figure 10 considers three starting debt ratios: one at 200 per cent of GDP, another at 100 per cent of GDP, and a third at 25 per cent of GDP. The figure shows how debt ratios would evolve over a decade for an illustrative i-g of -5 per cent (darkest lines), -2 per cent, and -1 per cent (lightest lines) and for a primary balance = 0. After ten years, a shock hits the system and the i-g differential narrows by two percentage points. While the debt dynamics remain favourable even after the shock, this changes the dynamics in important ways.[13]

Figure 10 highlights two features:

First, shocks to i-g can lead to materially worsening debt trajectories, especially when debt ratios are already high. As Figure 10 shows, the dynamics disimprove in all three cases. At the lowest debt levels, the impact is negligible. However, at higher debt ratios, the effect is substantial. For example, in the scenario where debt starts at 200 per cent of GDP, a 2 percentage point rise in i-g, from a starting point of 0 per cent, causes the debt trajectory to rise having been stable. The i-g value becomes positive (= +2 per cent). The rate of annual increase in debt ratios thereafter rises by 4 percentage points post-shock on average. Moreover, the rate of increase rises over time.

Second, the uncertainty around potential outcomes is larger at higher starting debt ratios. We can see from Figure 10 that the range around the outcomes for debt over the two-decade horizon is substantially wider for situations where the initial debt ratio is higher. The range for the three scenarios spans some 150 percentage points of GDP in the scenario with the higher starting debt ratio. The scenario with the lowest starting debt ratio only spans 19 percentage points.

### What might this entail for adjustments?

A key question is what fiscal response may be needed if these shocks where to materialise. One metric is to consider what measures to increase the primary balance would be needed to stabilise debt ratios if dynamics become less favourable.

To gauge this, we can explore how many years of standard 0.5 percentage points of GDP adjustments—similar to what the Stability and Growth Pact sets out—to the cyclically adjusted primary balance might be required to stabilise the debt ratio if debt dynamics were to become less favourable.[14]

[13] This entails an i-g of -3 per cent, 0 per cent and +1 per cent for each of the three lines in each scenario after period t+10.

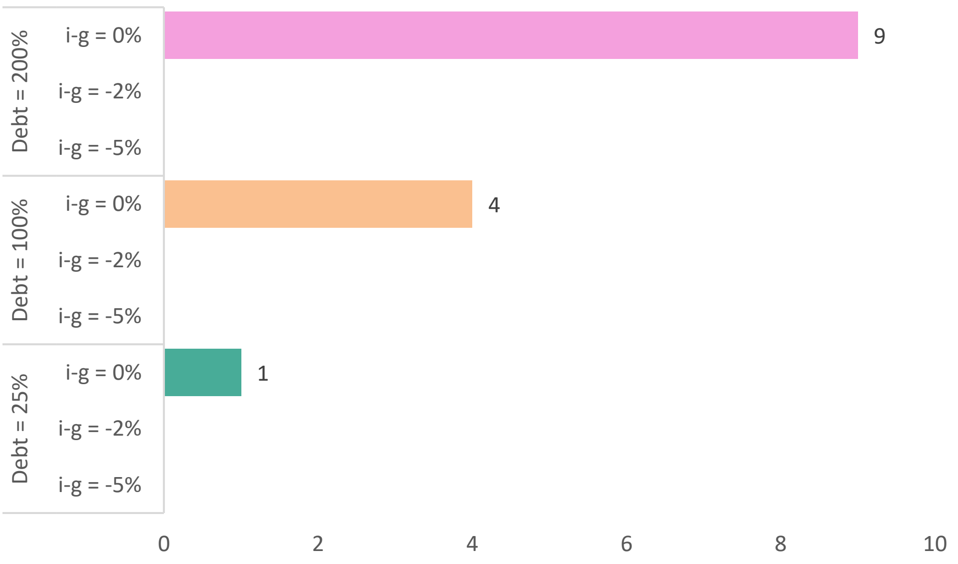
[14] Naturally, convergence towards the Stability and Growth Pact's target of 60 per cent debt to GDP ratio would require a more prolonged period of adjustment.

Based on the two-percentage point worsening of the interest-growth differential considered above, Figure 11 shows the number of years, if any, that a government would theoretically have to adjust its primary balance over in order to bring primary balances to a level that would stabilise debt.[15]

In the case of debt starting at 200 per cent and an initial i-g of 0 per cent, it would take some 9 years of incremental adjustments. This would entail bringing the primary balance from a balanced position to a surplus of +4.5 per cent and maintaining this for several years before debt stabilised. However, in the case of debt starting at 25 per cent of GDP, just 1 year of adjustment would be required to stabilise the debt ratio. This would entail bringing the primary balance from 0 per cent of GDP to 0.5 per cent. The middle scenario, where debt ratios start at 100 per cent of GDP, would entail 4 years of adjustments meaning that a primary balance of 2 per cent of GDP would be ultimately required.

## Figure 11: How long might governments have to adjust for?

Years of 0.5pp adjustments required to stabilise debt after a +2pp i-g shock




Sources: Own workings.
Notes: The chart shows the duration that incremental 0.5 percentage point adjustments would have to be made to the primary balance in structural terms so as to achieve a stable debt ratio following a +2 percentage point shock to the initial i-g configurations shown (consistent with a one percentage point reduction in g and a one percentage point rise in i).

Of course, the size of the primary balance being run also depends on economic conditions. Faster economic growth would help to raise revenues, hence making it

[15] Note that this assumes that the adjustments are structural in nature and, crudely, that there are no feedback effects to growth or inflation.

easier to generate larger surpluses. It would also tend to lower spending on unemployment benefits. And faster economic growth can make it less damaging both economically and politically for governments to pursue consolidation measures that raise structural balances to higher levels. Moreover, having additional fiscal space to respond to a shock can allow governments to smooth their responses, hence mitigating potential scarring and improving growth prospects.

As Figure 11 implies, an unexpected shock to interest rates and growth at high debt levels could have major implications for fiscal policy over many years. First, tightening policy for many years would have a large cumulative dampening effect on demand. Maintaining a high primary surplus would involve a persistent imbalance between the tax revenues raised and the government spending injected into the economy. Second, this could be difficult to sustain politically and socially. One risk is that the public investment would be depressed over a long period, undermining the potential output of the economy.

These effects would be amplified in terms of the headline budget balance. With higher interest rates, more of government spending would need to be allocated to interest payments. If investors are less likely to spend out of income than the general population, this will be a further drag on demand. In small open economies where debt is largely held by foreigners, this concern may be particularly serious. It could be partly mitigated by central bank ownership of government debt as much of the interest is returned to the government through central bank profits.

## 3. Headwinds from ageing costs

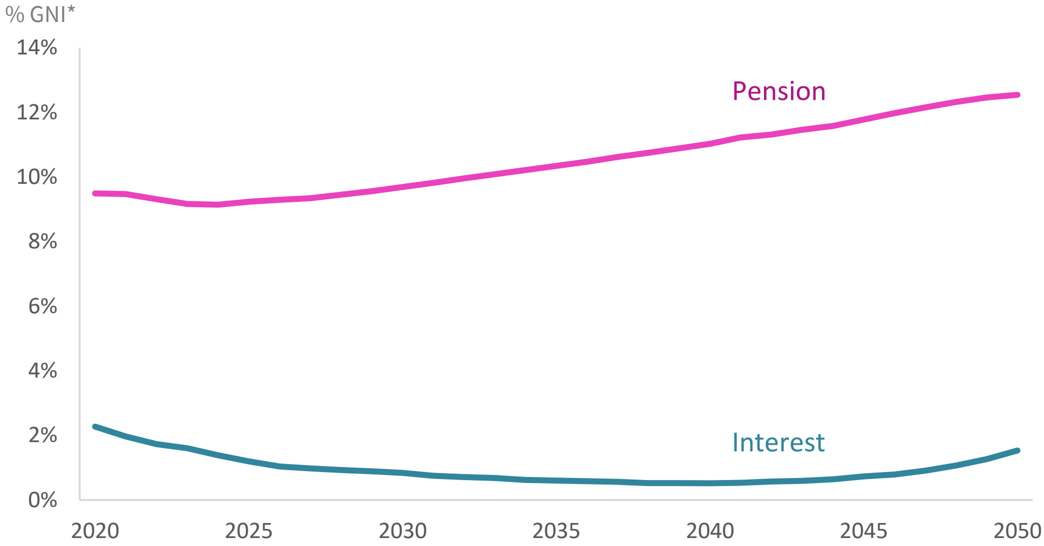
The overall sustainability of the public finances depends not only on the dynamics of government debt, but also a range of other explicit or implicit commitments. Here, commitments to future pension's costs loom large in the public finances: most euro area countries are currently spending around 12.3 per cent of GDP on pensions, far more than the 1.5 per cent being spent on gross interest costs. These commitments represent both a challenge in themselves as well as potentially making it more complicated to manage public debt in the future.

While pensions costs are not a commitment in the same sense as the legal commitment to make coupon and principal payments on government bonds, they may be viewed as embodying a future commitment to citizens compared to other forms of spending that are more discretionary. Pay-as-you-go pension systems embody a promise to current taxpayers that they will receive future benefits and are more sensitive to demographic changes over time than fully-funded systems. While pension reforms can reduce these burdens on the public finances, they may be politically difficult to implement. The economic implications of ageing populations have received increasing attention from economists and policymakers, and have been flagged at both the institutional level (OECD, 2019; IMF, 2019; European Commission, 2018) and among researchers in recent years (e.g. Goodhart and Pradhan, 2020; Acemoglu and Restrepo, 2017; Bloom et al. 2011; Maestas et al. 2016).

Future pension commitments can be evaluated as a stock with similar dynamics to the stock of government debt. However, the data required to accurately calculate these stocks is rarely forthcoming. This would require detailed information on both payments into the system and the accumulation of expected further payouts. A further step is to develop a measure of the net present value of future pension commitments, but this requires many assumptions (see IMF, 2011). While this approach provides useful insights, the long time horizons of these commitments means discounting and growth assumptions play a big role in determining these stocks.[16]

A different way to assess the role of pensions is simply to look at flow of expected future payments and to compare them to interest payments and the growth of the economy. As demonstrated by the data for Ireland in Figure 12, the key issue is that pensions payments are already far higher than interest repayments and will rise faster than income over time as the population ages with people living longer and more people reaching retirement ages, in some cases offset by planned pension reforms or changes in pension parameters.

## Figure 12: Pensions spending is far larger and rising faster than interest repayments in Ireland




Source: NTMA, Department of Finance, and Fiscal Council workings.
Notes: Pension spending includes public sector pension costs. Interest repayments include all general government interest payments on marketable and non-marketable debt.

We explore this issue through the Long-Term Model (LTM) for Ireland developed by the Fiscal Council (2020) — see Annex B for a review. Starting with our baseline assumptions, we can trace through the impact that pensions costs are likely to have on the change in debt ratios in coming years. This is under the assumption that policy follows a "business" as a usual approach where revenues and non-pension primary spending grow in line with national income. Pensions costs are assumed to rise in line with national income as a result of the indexation of payments and an

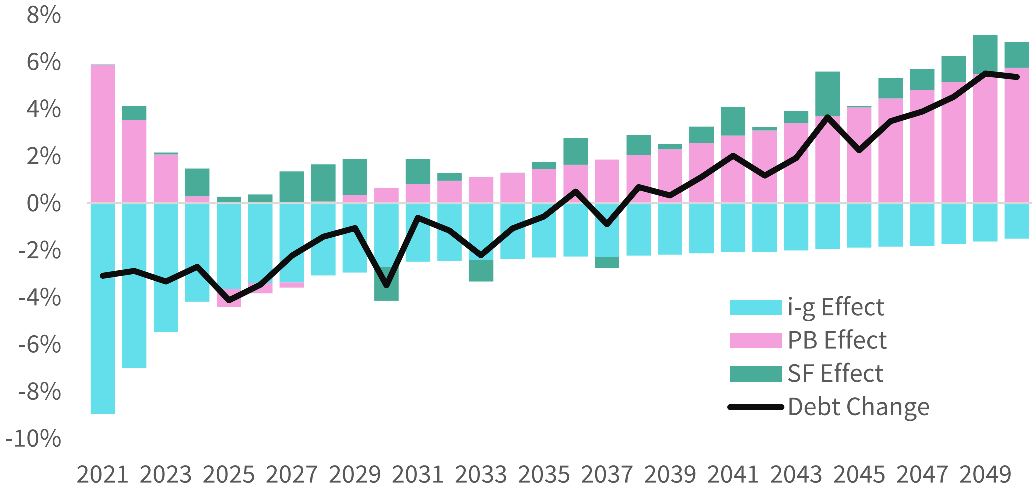
[16] Recent estimates for Ireland have calculated the present value of pension commitments from the state at approximately €150 billion (DPER, 2020)

additional term due to the change in the number of pensioners resulting from rising life expectancy and larger cohorts reaching retirement age. We also assume that, as per the enactment of the Social Welfare Bill 2020, the retirement age remains at 66 for the duration of the forecast horizon.[17]

As Figure 13 shows, our decomposition given by Equation (1) indicates that pensions costs are projected to contribute some 60 percentage points in deficit widening expenditures between 2030 and 2050, assuming balanced revenues and expenditures in other areas. This is estimated to be offset by favourable debt dynamics to result in an overall cumulative 26 percentage point rise in debt ratios from 2030 to 2050.

## Figure 13: Pensions-related spending will drive up debt ratios

Contributions to Debt Change Y/Y (percentage points)

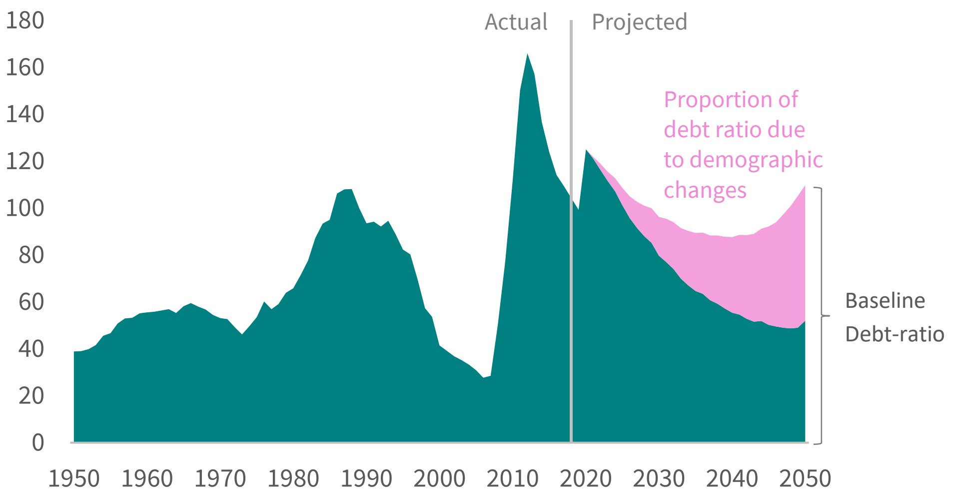



Source: Own workings.
Notes: The i-g effect is the impact of the interest-growth differential on debt ratios; the PB effect is the primary balance; and the SF effect is the expected impact from stock-flow adjustments (such as changes in cash balances).

Under current policies, ageing-related costs will add to the debt burden, diverting it from a steady decline from 2025 to reach a higher trough before rising again. As Figure 14 shows, the pink shaded region shows the proportion of the baseline debt ratio that can be attributed to an ageing population relative to 2020 demographics. Around half the debt burden in 2050 is projected to reflect unfunded ageing costs.

[17] The bill resulted in planned increases to the pensionable age to 67 and 68 in 2021 and 2028 respectively being repealed. See: DEASP (2020) for details.

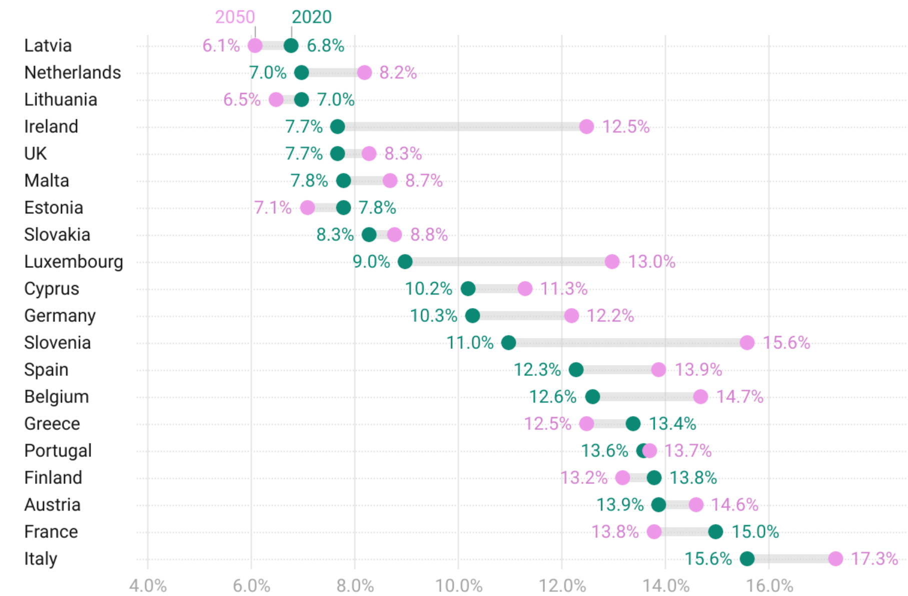
## Figure 14: Ageing costs will prevent debt ratios from falling




Source: Fiscal Council workings.

As Figure 15 below shows, these increases are not unique to Ireland, with pensions expenditures set to rise considerably across EU members in future. For example, in Italy, the estimated annual cost of pensions commitments as a share of output is forecast to rise from an already high figure of 15.6 per cent of GDP in 2020 to 17.3 per cent in 2050.

## Figure 15: Demographic pressures are expected to add to pensions spending in many European countries




Source: EU Ageing Report, Own workings.

We can combine these estimates and examine the interaction between spending on pensions in the economy in a given year and the contemporaneous debt dynamics for each country. We do this by estimating the 'stock' of accumulated pensions shortfalls over the coming decades through the following equation:

$$\sum_{t=1}^{T} P_i = P_{it-1}\left(\frac{i_t - g_{it}}{1+g_{it}}\right) + P_{it} \qquad (7)$$

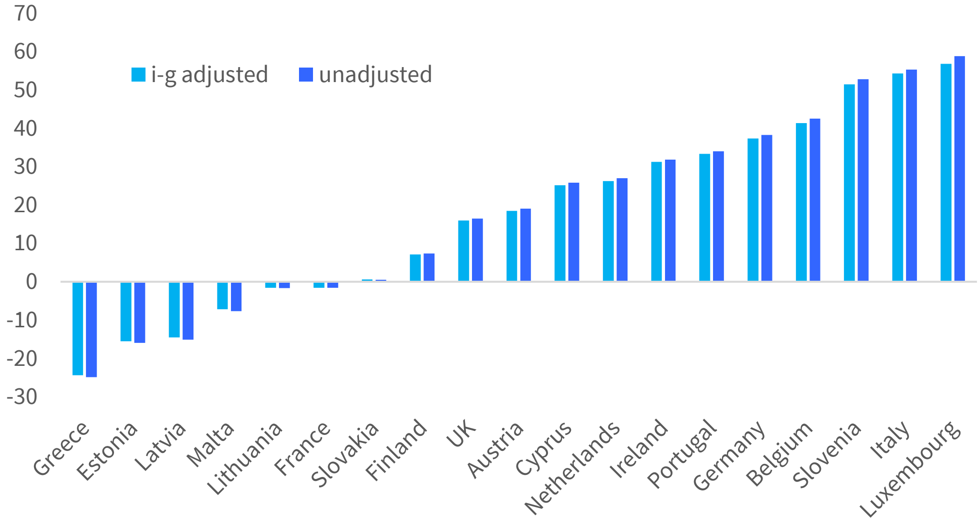
where $P_{it}$ is gross annual pension spending. In this exercise, we assume that the interest rate path of all countries follows the same trajectory to end-2050 at 1.3 per cent, while growth rates follow medium term potential output estimates, and the pensions shortfalls equal each year's excess over 2020 figures. Figure 16 shows the results for a selection of European economies.

The findings of this exercise assessing pension payments as a stock demonstrate two important points. First, the stock of shortfalls in pensions spending between 2020 and 2050 is substantial and will exert an incremental and considerable pressure on public finances around Europe. Second, while debt dynamics are favourable, by breaking the debt stock into a pensions and non-pensions component, we can see that the tailwind from i<g dynamics does not serve to significantly reduce the overall stock of shortfalls facing policymakers. Taken together, this implies that even assuming favourable debt dynamics for an economy that faces no shocks over the coming decades, the burden of unfunded pensions commitments warrants particular attention.

These dynamics have important implications for the sustainability of the public finances and welfare more generally. First, as discussed, these commitments are in substantial in size, running to several times current spending on regular bond repayments without being included in the government's stock of marketable debt.

## Figure 16: Accumulated impact of pensions outlays

% GDP (GNI* for Ireland), general government pension spending 2020–2050




Source: EU Ageing Report, Own workings.
Notes: The figure shows the 'stock' of accumulated pensions outlays from 2020–2050. The i-g adjustment is intended to show the contemporaneous debt dynamics associated with this stock.

Second, recent evidence shows that political administrations can face considerable difficulties in implementing pension reforms, suggesting that pension liabilities should not be so readily discounted from the traditional budget constraint a government is subject to. Kotlikoff (2019) and others such as Auerbach et al. in earlier work (1994) have been drawing attention to this problem for some time in the context of the US, although the fundamental argument does not change for European sovereigns. Rogoff (2020), for example, likens pension commitments to a type of 'junior debt' that can dwarf the size of official debt, while going further to suggest that the assumption that governments are more likely to default on pension commitments than 'senior' sovereign debt has yet to be fully tested in the current environment.

Third, while tailwinds from growth and bond market conditions ease these pressures, there is reason to suggest that such conditions can actually lead to increase the debt burden and associated risks. Yared (2019) for example notes that favourable conditions are associated with trend increases in the debt stock that cannot be explained by the neoclassical determinants, but rather by ageing demographics, and other political economy factors. Earlier work by Bohn (2008; 2010) characterises such practices as risking the 'privilege' of relatively unconstrained access to credit. With one of the most serious consequences of rising debt and greater liabilities from ageing acting to all equal, increase doubts over the solvency of the government and monetary stability more broadly.

Fourth, ageing populations will not just lead to continuously growing liabilities through unfunded pensions and health care provision, but they will also act as a drag on potential output as working age populations decline. Goodhart and Pradhan (2020) tie these factors together into an overall outlook for advanced economies that is characterised by lower growth, higher inflation, and weaker public finances.

The Covid-19 crisis has likely exacerbated some of the structural problems facing policymakers in the decades ahead. The fiscal hit to governments from the crisis has naturally lead to lower tax revenues that would ordinarily fund pension expenditure, while contributions from employers to private pensions will also be lower. Additionally, lower interest rates will see returns to private pension funds drop further, increasing implicit pension liabilities for governments.

Indirectly, there could be other factors that increase pressures from pensions. Early retirement may increase as in previous recessions (Munnell and Rutledge, 2013), while demographic pressures may increase due to financial uncertainty and low social interaction and family building among younger cohorts.

From a policy perspective, there are a number of steps that could be employed to both increase fiscal sustainability of the pensions system, while also promoting intergenerational equality among cohorts. Linking both the age at which the state pension is payable, along with the overall benefit to life expectancy are two ways to address the main concerns of fiscal risks and societal equality. Automatic balancing mechanisms are another set of tools that policymakers can employ to address pension imbalances.

## 4. Conclusions

High debt and a favourable interest-growth differential have created a new "high-altitude" public debt regime. This is marked by high debt ratios and an expectation that interest rates will remain relatively low compared to economic growth rates. The resulting negative growth-interest differential creates very favourable dynamics for public debt. This eases the limits on the sustainable level of debt or the primary balance. It also means that many countries should be able to benefit from relatively fast debt ratio reductions in the early stages of a post-Covid recovery.

However, higher levels of debt also increase the sensitivity to interest rate rises and shortfalls in growth rates, hence creating instability. This is evidenced by the magnifying role that higher starting debt ratios have on shocks to the interest-growth rate differential. This compounds usual uncertainties about future growth rates and interest rates and creates greater uncertainty about the path for government debt ratios.

Rising pension and healthcare spending in the coming years creates significant headwinds for the public finances in coming decades. This will tend to raise debt ratios further without action to improve sustainability. At the same time, potential output will gradually lessen and lead to lower long term economic growth rates, increasing vulnerabilities to shocks in future.

Taken together, the analysis in this paper suggests that the additional fiscal space created by favourable debt dynamics can be used to address the Covid-19 crisis and to take measures to boost potential output, such as higher investment. However, this space should be used cautiously, given the heightened risks at high altitudes of debt and the headwinds posed by population ageing.

While governments can use additional fiscal space and benefit from swift declines in debt ratios due to favourable dynamics, a credible medium-term plan for fiscal policy is needed. This should anchor the debt ratio over the medium term by identifying a realistic path for spending and taxation that delivers this. The path should allow space for adjustment if conditions deteriorate, which would be prudent. This would include ultimately aiming for a primary balance that is sufficient to maintain the debt ratio on a downward path.

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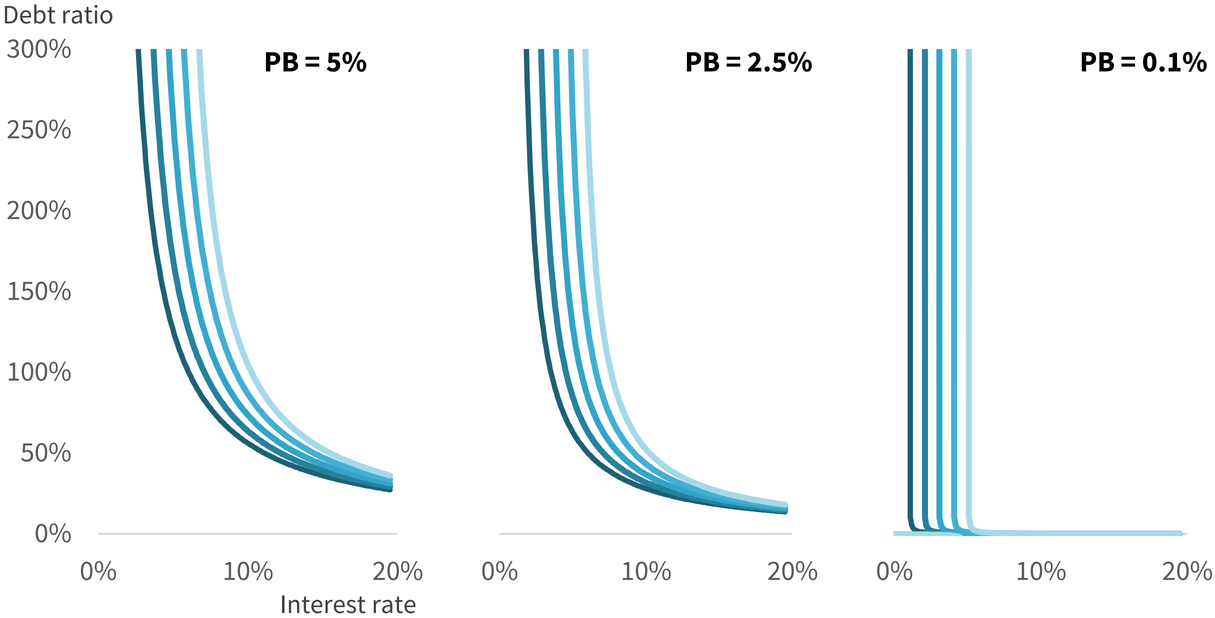
## Annex A

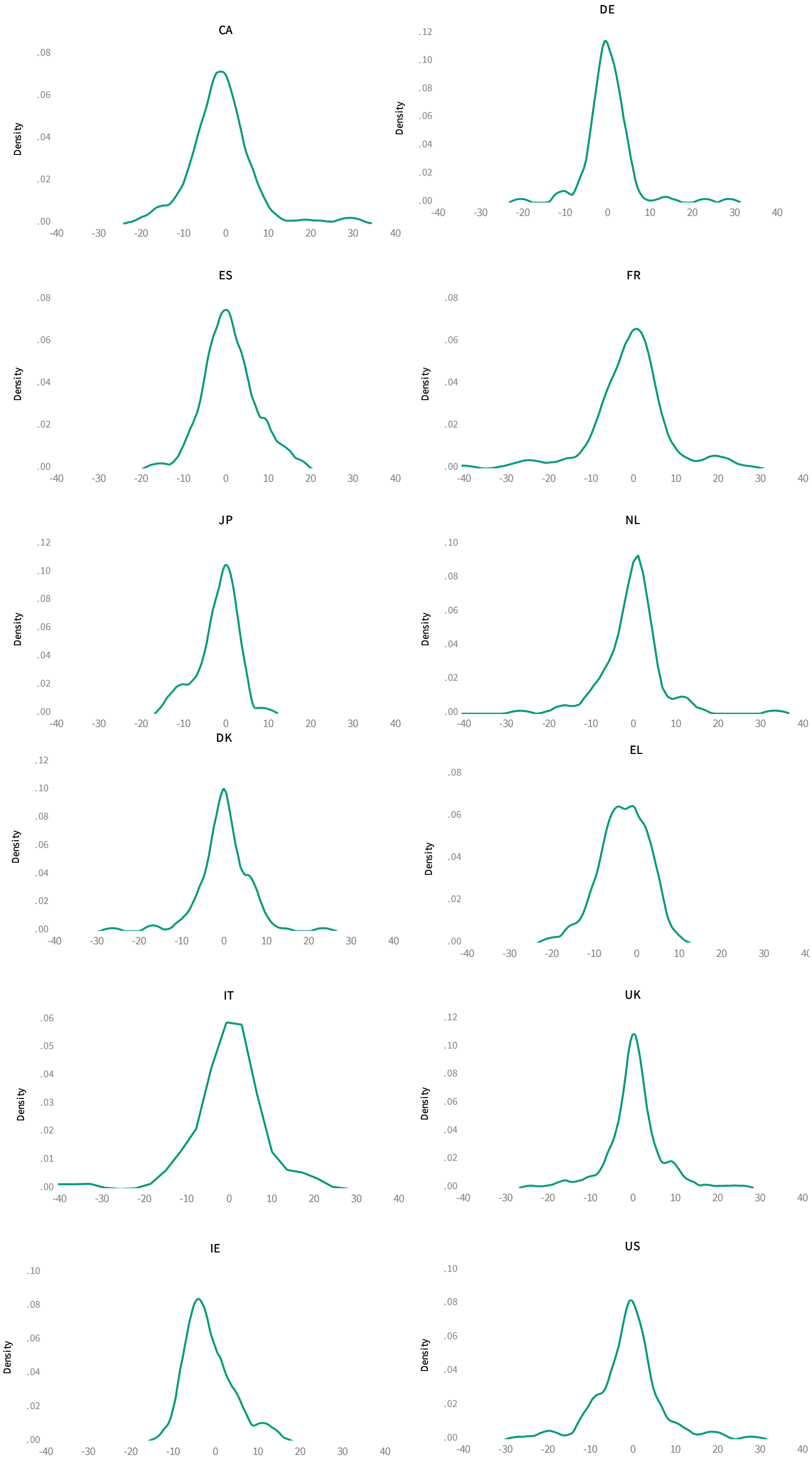
This annex sets out some accompanying charts and tables to the earlier analysis.

### Figure A: Debt limits




Notes: The charts show corresponding debt ratio limits for different primary balances (shown in the charts) and different i and g configurations. The lines from left to right are for growth (g) = 1%, 2%, 3%, 4%, and 5%, respectively.

## Figure B: Distributions of i-g for selected countries




Sources: IMF ModHist (Mauro et al 2013); own workings.
Notes: The chart shows the distribution of r-g values for the G7 + Ireland, Spain, Greece, Netherlands, and Denmark, where real growth and interest rates are used. The sample period varies but runs to 2011, with earliest observations: UK 1831, IT 1862, CA/DK/FR/DE/US/NL 1881, ES 1882, EL 1961, IE 1964, and JP 1966.

## Annex B: The Long-Term Model (LTM)

The LTM was built to develop demographic and macroeconomic projections and is outlined in detail in Fiscal Council (2020). It incorporates:

1) **a cohort-component model** used to develop population dynamics. This approach projects population by gender and age as a function of developments on fertility rates, survival probabilities and migration flows based on single-year age cohorts of the latest official population estimates (CSO, 2019). This methodology is widely used by national statistics offices and forecasting bodies at an international level.

   As a first step, the portion of the population that survived from period t-1 to period t is calculated, and the projected net migration flows for the period are added. This part of the process excludes the new-borns of the period, which are calculated in a second step by applying the age-specific fertility rates to the surviving women, and adjusting for the probability of the new-born's gender. Equation (7) shows the functioning of the cohortcomponent model as applied in this report, which is represented in matrix form through a time-dependent first-order Markov chain (Luenberger, 1979; Girosi & King, 2008).The vectors contain as many rows as age groups (in the range of 1 to X) per gender, the first half corresponding to men G=1, and the second half to women G=2.

$$
\begin{bmatrix} N_{1,1,t} \\ \vdots \\ \vdots \\ N_{X,1,t} \\ N_{1,2,t} \\ \vdots \\ \vdots \\ N_{X,2,t} \end{bmatrix}
=
\begin{bmatrix}
0 & \cdots & \cdots & 0 & F_{1,2,t-1} & \cdots & \cdots & F_{X,2,t-1} \\
S_{2,1,t-1} & & & \vdots & 0 & 0 & & 0 \\
\vdots & \ddots & & \vdots & \vdots & & \ddots & \vdots \\
0 & \cdots & S_{X,1,t-1} & 0 & 0 & 0 & \cdots & 0 \\
0 & \cdots & \cdots & 0 & F_{1,2,t-1} & \cdots & \cdots & F_{X,2,t-1} \\
\vdots & & & \vdots & S_{2,2,t-1} & 0 & 0 & \vdots \\
\vdots & & & \vdots & \vdots & \ddots & 0 & \vdots \\
0 & \cdots & \cdots & 0 & 0 & \cdots & S_{X,2,t-1} & 0
\end{bmatrix}
\times
\begin{bmatrix} N_{1,1,t-1} \\ \vdots \\ \vdots \\ N_{X,1,t-1} \\ N_{1,2,t-1} \\ \vdots \\ \vdots \\ N_{X,2,t-1} \end{bmatrix}
+
\begin{bmatrix} M_{1,1,t} \\ \vdots \\ \vdots \\ M_{X,1,t} \\ M_{1,2,t} \\ \vdots \\ \vdots \\ M_{X,2,t} \end{bmatrix}
-
\begin{bmatrix} E_{1,1,t} \\ \vdots \\ \vdots \\ E_{X,1,t} \\ E_{1,2,t} \\ \vdots \\ \vdots \\ E_{X,2,t} \end{bmatrix}
\quad (7)
$$

Source: Osés-Arranz and Quilis (2018).
Note: N refers to the population; S, to the survival probabilities; F, to the fertility rates; M, not the immigration flows; and E, to the emigration flows. The first sub-index denotes the age group of the cohort, where age = [1, X] and X = 100 in this exercise. Fertility rates are non-zero only for the fertile age of the mothers, assumed to be between 15 and 49 in this exercise. The second sub-index refers to the gender, where gender = [1, 2] refers to male and female, respectively. The last sub-index refers to the current period t, and to the previous period t-1.

2) **a gravity model of bilateral migration flows**. Migration is typically the most challenging demographic component to forecast and the main source of error in population projections. This is especially the case in Ireland, a small open economy where migration flows are particularly volatile. Migration can have important effects on the overall size of the population, and potentially on ageing if migrants—who typically move at relatively young ages—stay in the country over long horizons. With this in mind, well-founded migration projections are paramount.

Drawing on international data on global bilateral migration and strong developments in migration estimation techniques, the gravity model of migration, with a special focus on Ireland. The gravity model draws on international data and recent modelling techniques to project world migration in a bilateral fashion. It relates country-pair migration flows with fundamentals like economic growth, demographics, and other relevant variables. The equation underpinning the migration projections is shown in Equation (8) and further details of how the model is specified are provided in Osés-Arranz (2019).

$$odds_{o,d,t} = exp\left(\delta_0 * lnM_{o,d,t-1} + \sum_i \delta_{1,i} * lnPop_{i,o,t-1} + \sum_i \delta_{2,i} * lnPop_{i,d,t-1} + \delta_3 * lnGDPc_{o,t-1} + \delta_4 * lnGDPc_{d,t-1} + \delta_{5,o,d} * MRM_{o,d,t}\right) + \alpha_{o,d,t} \quad (8)$$

$$\forall o \neq d, \text{where } o = 1, \ldots, 232; d = 1, \ldots, 232; t = 1970, \ldots, 2020; i = [15^{-}, 15-64, 64^{+}]$$

Source: Osés-Arranz (2019).

3) **a Solow growth model for projecting economic activity.** As shown in Equation (9), real GNI* growth ($\Delta Y_t$) is the sum of the growth rate of total factor productivity (TFP) ($\Delta A_t$), and the weighted growth rates of the net capital stock ($\Delta K_t$) and labour inputs ($\Delta L_t$). We assume standard elasticities of output with respect to capital (α=0.33) and labour (1−α=0.67).

$$\Delta Y_t = \Delta A_t + \alpha \Delta K_t + (1-\alpha)\Delta L_t \quad (9)$$

Labour inputs are given by our assumptions on demographics, participation rates, average hours worked and the steady state unemployment rate.[18] The net capital stock (K) is defined as the previous period's stock minus depreciation and plus investment (I).[19] As in other long-term forecasts, the LTM treats productivity growth as exogenous. This broadly follows the approaches adopted in, for example, McQuinn and Whelan (2015); the EU Ageing Reports; the UK's Office for Budget Responsibility's (OBR) Fiscal Sustainability Reports; and the OECD's long-run projections among others.

4) **an interest model.** Interest costs in the LTM are modelled based on borrowing costs for currently held debt and an endogenous projected cost of servicing future gross general government debt. This means the projected cost of future borrowings may increase over time in response to

[18] When combined, these series give an estimate of the total hours worked in the economy in a given year ($L_t$), which serves as our labour input to growth: $L_t = Avghrs_t * (1 - une_t) * (pop_t * PR_t)$

[19] An adjusted net capital stock based on the concept of Domestic GVA and obtained from the CSO is used: $K_t = (1-\delta)K_{t-1} + I_{t-1}$. This strips out distortions associated with foreign-owned multinational enterprises. For the projection period, it is assumed that the depreciation rate (δ) stays constant at its last available outturn. Investment rates are broadly assumed to stay close to long-run levels for private investment, and to stay at planned rates for public investment.

rising government debt, depending on interactions with other factors. The LTM incorporates feedbacks on the marginal 10-year yield (MIR), which is the key determinant of interest costs (Casey and Purdue, 2021):

$$MIR_t = \beta_1 MIR_{t-1} + \ \Delta PolicyRate_t + \beta_2 \left( \Delta \frac{GGDebt_t}{GNI^*_t} * \left( \frac{\frac{GGDebt_t}{GNI^*_t}}{60\%} \right) \right) \quad (10)$$