WORKING PAPER

SHOULD WE WORRY ABOUT PUBLIC DEBT? AN EMPIRICAL ANALYSIS OF *r - g* IN OECD COUNTRIES.

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Should we worry about public debt? An empirical analysis of $r - g$ in OECD countries.

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Abstract

The difference between the implicit nominal interest rate and the growth rate of nominal GDP is a key determinant of the dynamics and the sustainability of public debt. This paper studies the determinants of $r - g$ in a panel of 17 OECD countries since the early 1980s. Whereas the focus of existing studies is mainly on fiscal, monetary and financial drivers of the interest–growth difference, our approach and contribution are to include and highlight in particular the impact of real long-run drivers, such as technical progress, employment growth, components of demographic change, and income inequality. This allows us to derive empirically based projections for $r - g$ beyond the next five or ten years. Our projections suggest that $r - g$ remains negative for the next two decades in most European countries that we study, but not in the United States. The debt-carrying capacity of governments in Europe is structurally higher now than in recent decades. This allows to worry less about public debt, but does not exempt policy makers from the task to strongly monitor their expenditures and balances, given major challenges ahead.

Keywords : public debt, $r - g$, fiscal sustainability, fiscal rules, demographic change, inequality

JEL Codes : E43; E62; H63; H68; J11

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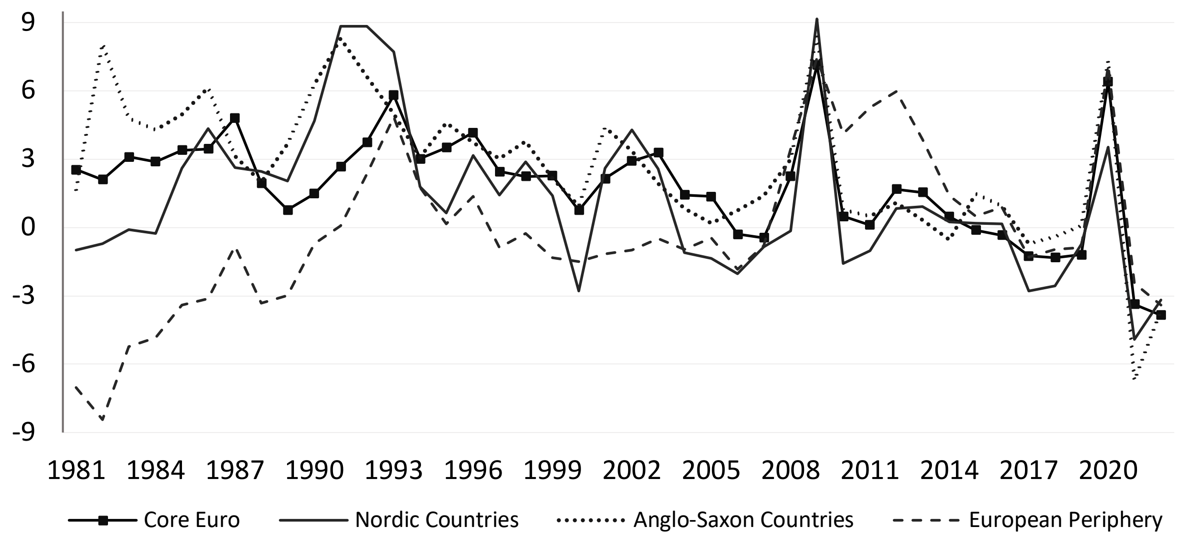
1. Introduction

The difference between the implicit nominal interest rate and the growth rate of nominal GDP is a key determinant of the dynamics and the sustainability of public debt. While this difference was positive in the OECD most of the time in 1981-2014, it turned negative in 2015 (Figure 1). Although the covid-19 recession interrupted the negative series for $r - g$ in 2020, OECD data and projections for 2021-2022 suggest that this interruption will be limited to only one year. For governments, this is of major importance. If structural, a negative $r - g$ allows highly indebted governments to gradually reduce their debt in percent of GDP without having to run primary surpluses. Even with a primary deficit, debt will not explode.[1] It will be sustainable, at least if it can be assumed that the primary deficit and the level of debt have no dramatic effect on the interest rate due to crowding out effects or rising sovereign risk premia. In times of a high need for public investment, this offers a great opportunity.

Our first goal in this paper is to explain the gap between the implicit interest rate on public debt and the growth rate of GDP in a panel of 17 OECD countries since 1981. Although we will also control for a set of short-run and nominal determinants and unobserved common factors, the specification of our empirical model is inspired mainly by theory on the real long-run drivers of the interest rate and the economic growth rate. This long-run perspective allows us, as a second objective, to make projections for $r - g$ in the next two decades. Last, our panel regression results and these projections enable us to draw informed conclusions about the sustainability of public debt in the countries studied, and its implications for future fiscal governance.

Figure 1. interest–growth difference in 4 country groups (1981-2022, in percentage points)



Sources: OECD, IMF. Details on the construction and the sources of these variables are reported in Appendix 1. Projections for 2021-2022 are mainly based on OECD (2021, *Economic Outlook*, n° 109).

Note: The reported series are unweighted averages for the countries included in each group. The Core euro group contains Austria, Belgium, France, Germany and the Netherlands. The Nordic group includes Denmark, Finland, Norway and Sweden. The included Anglo-Saxon countries are Canada, the United Kingdom and the United States. The European Periphery group contains Greece, Ireland, Italy, Portugal and Spain.

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[1] See for example Blanchard (2019) and Blanchard et al. (2021). Assuming a constant primary deficit $\bar{d}$, and given interest and growth rates, it can be shown that the debt ratio will converge to a sustainable finite value equal to $\frac{\bar{d}(1+g)}{(g-r)}$.

Our paper intends to contribute to two strands of recent literature. First, several other studies have recently analyzed the difference between the implicit nominal interest rate on public debt and nominal GDP growth for varying samples of countries, e.g. Turner and Spinelli (2011) for OECD countries, Escolano et al. (2017), Presbitero and Wiriadinata (2020) and Mauro and Zhou (2021) for advanced and emerging economies, and Checherita-Westphal and Domingues Semeano (2020) for euro area countries. Whereas the focus of these papers is mainly on fiscal, monetary and financial drivers of the interest–growth gap, our approach and contribution are to highlight in particular the impact of real long-run drivers, such as technical progress, different components of demographic change (including the growth of labour supply) and income inequality. This also allows us to derive empirically based projections for $r - g$ beyond the next five or ten years. Second, our paper's results are relevant for the current discussion on public debt sustainability and fiscal rules in the aftermath of the huge public debt increase during and after the covid-19 recession (see e.g. EFB, 2020; Mauro and Zhou, 2021; Blanchard et al., 2021; IMF, 2021; ESM, 2021; Martin et al., 2021). Projections for $r - g$ are key to determine the primary balance required for the achievement of public debt targets. Our finding that $r - g$ may remain negative in the next decades in many countries supports the argument that the debt-carrying capability of governments is structurally higher now than in the past.

The remainder of this paper is organized as follows. Section 2 surveys the literature on the drivers of $r - g$. Section 3 presents our empirical approach and results. Section 4 contains our projections for $r - g$ in the next two decades, and their implications for the discussion on public debt targets and sustainability. Section 5 summarizes our main findings and advances some policy implications.

2. Determinants of r and $r - g$: review of the literature

We first discuss the impact of fundamental drivers suggested by long-run growth theory. We focus on the role of technical progress, demography, inequality, and fiscal policy and public debt. Then, we go into the effect of a set of additional variables of a more short-term nature: monetary policy, inflation, and specific crises.

2.1. Long-run drivers

In standard growth theory a higher *rate of technical progress* consistently implies a higher long-run economic growth rate and a higher real interest rate. Its theoretical impact on $r - g$ is therefore ambiguous.

As an illustration, consider the benchmark neoclassical model of Mankiw et al. (1992). In steady state equilibrium aggregate economic growth in this model is equal to $n + x$, with n the (employed) population growth rate and x the rate of technical progress. An increase in the rate of technical progress has a one-to-one positive effect on equilibrium growth. Given the assumption of perfect competition and absence of uncertainty or frictions, the equilibrium real interest rate in the model will be equal to the marginal product of capital (MPK), net of depreciation. Mankiw et al. show that $MPK = \frac{\alpha(n+x+\delta)}{s_k}$, with n and x as defined before, α the capital share in output, δ the capital depreciation rate, and s_k the fraction of output invested in physical capital. All these determinants are taken exogenous in their model. The positive effect of faster technical progress on the interest rate is then easy to see. Its effect on the interest – growth difference, however, is ambiguous. Whether $r - g$ rises or falls in x depends on whether $\frac{\alpha}{s_k}$ is greater or smaller than 1, at least in a 'perfect' world. The more imperfections and uncertainty disturb the close relationship between MPK and r, the more likely it is that $r - g$ falls in x.

Another benchmark macroeconomic model, the infinite-horizon representative agent Ramsey model, generates the same prediction for real GDP growth in equilibrium. In the Ramsey model this is also equal to $n + x$. The determinants of the interest rate depend on assumptions regarding the characteristics and the objective function of households. Heijdra (2017) assumes households that consist of infinitely-lived individuals and that optimize the intertemporal utility of its representative member. The Euler equation in the model then pins down the equilibrium real interest rate as $r = \rho + n + \theta x$, with ρ the rate of time preference, θ the inverse of the intertemporal elasticity of substitution, and x and n as defined before. An increase in technical progress raises households' future income. Since they want to smooth consumption over time, they will save less (borrow more) now, which implies a higher equilibrium interest rate.[2] Again, it is thus clear that faster technical progress raises both the economic growth rate and the interest rate. Its effect on $r - g$ is again ambiguous. It depends theoretically on whether θ is greater or smaller than 1. Under log utility, i.e. with θ tending to 1, there is no effect on $r - g$ in the Ramsey model.

When it comes to the data, a change in the rate of technical progress (TFP growth) will have a direct one-to-one long-run effect on productivity and output growth, everything else equal. Its influence on the real interest rate, however, is an issue of debate. Eggertsson et al. (2019, p. 38) and Rachel and Summers (2019, p. 42) suggest a more than proportional reaction of the real interest rate to changes in productivity growth. Rachel and Smith (2017, p. 14) rather assume a one-to-one relationship. Lunsford (2017) and Lunsford and West (2019) by contrast find no positive correlation between productivity growth and the real interest rate in the US. Hamilton et al. (2016) arrive at a similar conclusion. They call themselves skeptical of analysis that puts productivity growth at the center of real interest rate determination. If they are right, one would expect the relationship between changes in technical progress (TFP growth) and $r - g$ to be negative. In a direct empirical test of this relationship in the euro area countries since 1985, Checherita-Westphal and Domingues Semeano (2020) confirm this negative relationship.

A huge literature has investigated the impact of demography and *demographic change (ageing)* on economic growth and the real interest rate. Most of the research focuses on changes in four variables: the growth rate of population, the fraction of dependent older people, the fraction of dependent young people, and life expectancy.

The impact of *population growth* is strongly in line with that of technical progress, as discussed above, at least if it can be assumed that population growth will subsequently continue in employment. A rise in n directly affects the growth rate of GDP, and may thus reduce $r - g$. On the other hand, a higher (employed) population growth rate may also raise the interest rate. First, it increases the marginal product of capital. Second, at least in the specification of the Ramsey model described above, a higher population growth rate makes individuals save less. The reason is that in a growing household the individual return from

[2] The higher θ, the greater the households' preference for smooth consumption. The negative impact of a rise in x on savings will then be stronger. So will be its positive impact on r. Other models with optimizing individuals come to the same conclusion that faster technical progress would raise the interest rate because individuals save less. Eggertsson et al. (2019) for example find this in an overlapping generations model.

savings will be lower, since it will have to be shared with more family members in the future. Lower savings would imply a rise in the interest rate.[3] Combining both results, the theoretical effect from changes in population growth n on $r-g$ is again ambiguous. Unless n has a very strong impact on the marginal product of capital and the interest rate, one should expect this impact between -1 and 0. In the context of demographic change, falling population growth would then imply higher $r-g$ and bad news for the dynamics of public debt. Policies to enhance labour market participation and employment would reduce $r-g$.

Two developments explain a rapidly *rising old age dependency rate* (fraction of retirees in population). The first is the gradual retirement of the large baby boom generation, which implies growing numbers of new retirees. The second is increasing life expectancy, allowing those retirees to enjoy more years in retirement. Theoretically, these two elements will mainly affect the interest–growth difference via their impact on savings.[4] Because retirees save less than workers, a change in the composition of population towards more retirees should imply lower aggregate savings and higher interest rates. On the other hand, the expectation to live longer requires all individuals to collect more resources for future consumption. Along this channel, ageing may imply higher aggregate savings and lower interest rates. Li et al. (2007) confirm these two theoretical channels in panel data regressions for 149 countries in 1963-2003. As to their net effect, existing studies are fairly concordant in their conclusion that the second effect with lower interest rates dominates. Krueger and Ludwig (2007), Attanasio et al. (2016), Marchiori et al. (2017), Devriendt and Heylen (2020) and Gagnon et al. (2021), among others, obtain this conclusion from simulating demographic change in calibrated overlapping generations models for different (groups of) countries. Carvalho et al. (2016) find the same result in a calibrated life-cycle model. In general, all these models replicate a significant fraction of the drop in the real interest rate during the last decades. Interestingly, they also find very low real interest rates to persist for at least one or two more decades. Aksoy et al. (2019) find a net negative effect of growing fractions of people older than 60 on the interest rate in an estimated panel VAR model for 21 OECD countries in 1970-2014. Last, in their analysis of $r-g$ in the euro area Checherita-Westphal and Domingues Semeano (2020) also report a negative effect from the old-age dependency ratio. The fact that neither Aksoy et al. (2019) nor Checherita-Westphal and Domingues Semeano (2020) control for increasing life expectancy may rationalize this net negative effect.

Increased life expectancy may also imply that the standard distinction in traditional life-cycle theory between working and retired individuals (savers and dissavers) has become too simple. The perspective of a long life may motivate young retirees to continue saving. Studying a time series of four cross-sections of households in Finland, Kankaanranta (2019), for example, finds evidence supporting this hypothesis. Net household worth continues to increase in the years after retirement. Japelli (1999) found the same result for college-educated Italian households. In some of our empirical specifications we will therefore distinguish 'young' and 'old' retirees in percent of total population.

A fourth demographic variable is the *youth dependency rate*, the fraction of children in total population. Since these are consumers without earned income, one would expect a higher youth dependency rate to imply a lower aggregate savings rate, a higher interest rate

[3] Note, however, that a different setup of the Ramsey model may eliminate the impact of n on the equilibrium interest rate. Barro and Sala-i-Martin (2004) for example assume individuals with finite life belonging to (growing) immortal families. These families optimize the overall utility from consumption of the group, i.e. utility accumulated over all family members. The equilibrium interest then equals $r=\rho+\theta x$.

[4] An effect on growth may follow indirectly via interest rate effects on investment.

and a higher $r - g$. Li et al. (2007, footnote 12), however, find no significant effect on savings. Referring to other empirical studies on the effect of youth dependency, they conclude that there is no consensus, and results are typically not robust.

Changes in *income inequality* are expected to affect $r - g$ via both terms of the difference. The literature is fairly unanimous that a more unequal distribution raises aggregate savings, and hence brings a lower interest rate, because the rich save more (Carroll, 1998; Dynan et al., 2004; Cynamon and Fazzari, 2016; Eggertsson et al., 2019). Using this result, Rachel and Smith (2017) and Rachel and Summers (2019), among others, put forward rising income inequality as one of the drivers of declining real interest rates during the last decades. It is not the main factor, but may yet have contributed to an interest rate decline of about 0.5 percentage points. Eggertsson et al. (2019) report the same decline as result of a falling labour share in income.

The effect of income inequality on economic growth is subject of more controversy. OECD (2015) reviews the theoretical and empirical literature. In theory, higher inequality may promote growth for example because it fosters incentives to work, invest and undertake risks to benefit from high rewards. On the other hand, it may reduce growth when it inhibits poor individuals to invest in human capital, or when it is a source of political instability or social unrest. Recent empirical work tends to converge on finding a net negative effect from inequality on the long-run growth rate (e.g., OECD, 2015; Berg et al., 2018). For our purpose, combining the empirical effects from rising inequality on both r and g would leave us with ambiguous expectations regarding its effect on $r - g$. We know of no study having investigated this.

A great many researchers have looked into the effects of fiscal policy on real interest rates and long-run growth. Key fiscal variables of interest for our purpose are the *level of public debt* and the *(primary) financial balance*. The literature shows strong consensus that high levels of government debt and deficits reduce national savings and lead to higher interest rates. The hypothesis of Ricardian equivalence is mostly rejected. Summarizing seven studies in the literature, Rachel and Summers (2019, Table 2) report a 38 basis points increase in the interest rate, on average, after a 1 percentage point increase in the ratio of the public *deficit* to GDP. The interest rate rises by 3.5 basis points, on average, after a 1 percentage point increase in the ratio of public *debt* to GDP. Effects may be stronger, though, at very high debt levels. When lenders fear that public debt is no longer sustainable, rising risk premia will push up interest rates further. This leads to faster debt accumulation, which makes it even more likely that debt is unsustainable and may cause an additional increase in risk premia and interest rates (Paniagua et al., 2017; Blanchard, 2019; Lorenzoni and Werning, 2019; Presbitero and Wiriadinata, 2020).

In addition to the interest rate channel, most of the literature exploring the effects of higher public debt and deficits will conclude that $r - g$ rises also through the growth component. Growth may suffer for several reasons. A first one directly follows from higher interest rates, which deter investment in physical and human capital. Second, to ensure debt sustainability, governments facing growing interest payments may be forced to raise taxes or cut public investment, both undermining the economy's productive potential. Third, loss of fiscal policy as a stabilization instrument may imply larger macroeconomic volatility and uncertainty, which may also undermine investment and growth. Many empirical studies confirm this negative effect of public debt on subsequent growth (e.g. Reinhart and Rogoff, 2010; Eberhardt and Presbitero, 2015; Woo and Kumar, 2015; Chudik et al., 2017). Also here, thresholds seem to exist, i.e. public debt to GDP ratios beyond which effects on growth are significantly worse. Some studies put forward 90% (Reinhart and Rogoff, 2010; Woo and Kumar, 2015). Others, however, reject the idea that there should be a common threshold across countries (Eberhardt and Presbitero, 2015; Chudik et al., 2017).

Checherita-Westphal and Domingues Semeano (2020) confirm the existence of significant positive effects of public debt on $r - g$. In their base model, a 1 percentage point increase in the public debt ratio pushes $r - g$ almost 4 basis points higher. However, they find no non-linear threshold effect. A 1 percentage point decrease in the primary balance ratio in their study brings about a rise by almost 30 basis points in $r - g$.

2.2. Short-run drivers, control variables and unobserved common factors

Even though our attention in this paper is mainly focused on real long-run drivers of $r - g$, we will also include and control for a number of short-run and/or nominal variables. The literature highlights a few. Furthermore, we recognize the possible impact of relevant but hard to observe (and to measure) common factors behind the evolution of r or g in our studied group of countries.

Checherita-Westphal and Domingues Semeano (2020) point at the impact of (conventional and unconventional) *monetary policy*. They find significant positive effects on $r - g$ from the 3-month nominal interest rate, as well as from alternative policy related variables (Euribor, marginal lending facility rate). In addition, they test for the impact of asset purchases by the ECB and find them to reduce $r - g$. These results are in line with the existing empirical literature that unconventional monetary policy has contributed to lower sovereign bond yields and to higher economic growth and inflation (see e.g. Boeckx et al., 2017; Hesse et al., 2018; Hohberger et al., 2019).

Although both the interest rate r and the growth rate g in the equation for the dynamics of public debt are nominal variables, their reaction to *inflation* is very different. Nominal GDP growth will reflect higher prices of goods and services immediately and fully. The interest rate on public debt, however, will only capture changes in inflation with a delay, depending on the maturity of outstanding government bonds, and possibly also the prevalence of financial repression. As a result, rising inflation will at least in the short and medium run have a negative effect on $r - g$. As time goes on, and the market rate on new issued bonds also incorporates higher inflation, this negative effect is expected to disappear. In the same vein, Mauro and Zhou (2021) explain how higher inflation and financial repression in emerging economies caused a lower interest – growth difference in these economies compared to advanced countries in 1975-95. Escolano et al. (2017) report similar findings.

To capture *business cycle effects*, a standard approach in the literature is to include the output gap. We will follow this approach. Furthermore, crisis or other dummies could be added to account for unique temporary effects related to specific periods in particular countries. For example, in some of their estimated equations for $r - g$, Checherita-Westphal and Domingues Semeano (2020) add dummies to capture the specific effects, if any, of the financial crisis after 2007 and the European sovereign debt crisis in 2010-13. They also include a dummy to capture the effect of euro area membership. In our regressions we will also test for such specific effects.

Last but not least, researchers have pointed to the possible influence on r or g of developments at the global level which are deemed important, but which are hard to measure and which may affect each country differently. Different effects may, for example, result from different policies or different structural characteristics such as the degree of openness of the economy or the characteristics of the financial system. As examples of such developments, one may think of the global trend towards financial liberalization since the 1980s, the increasing concentration and rise of market power of (big) firms, the preference shift towards higher saving by emerging market governments after the Asian crisis in 1998, shifts in risk aversion and the increase in the demand for safe assets due to regulatory changes after the financial crisis (Rachel and Smith, 2017; Fahri and Gourio, 2018; Jordà et al., 2019). When not accounted for empirically, these common factors will become part of the error term and affect the quality of the estimation results. We discuss how we deal with this in the next section.

3. Empirical analysis of $r-g$

3.1. Empirical model

The empirical model that we estimate emerges directly from the theoretical discussion of the determinants of $r-g$ in the previous section. It can be summarized as follows:

$$(r-g)_{it} = \alpha_i + \beta' X_{it} + v_{it} \tag{1}$$

$$v_{it} = \lambda_i f_t + \varepsilon_{it} \tag{2}$$

where $(r-g)_{it}$ is the interest–growth difference on general government debt in country i and year t. On the right of Equation (1), α_i denotes the country-specific fixed effect for country i, X_{it} the vector of explanatory variables, β a vector of parameters to be estimated, and v_{it} the error term. In Equation (2) we allow for the impact of unobserved common factors, captured by f_t, with a country-specific effect λ_i. In the spirit of Pesaran (2006) we include the cross-sectional average of the dependent variable as our proxy for f_t.[5] The model given by (1) and (2) can thus be seen as an extension of the fixed effects estimator that allows for cross-sectional dependence in the error term due to unobserved common factors.

Table 1 provides a detailed description of all explanatory variables that we consider.

3.2. Data and time series properties

Unsurprisingly, considering the likely impact of unobserved common factors that we discussed at the end of Section 2, the CD test of Pesaran (2004) confirms the existence of positive *cross-sectional correlation* in $r-g$, both in levels and in first differences.[6] This observation justifies the specific error structure that we adopt in Equations (1) and (2). Moreover, if cross-sectional correlation remains in the error term of our regressions, this can lead to biased standard error estimates, and usual inference tests will be invalid. We deal with this potential problem using Driscoll and Kraay's (1998) correction, which provides robust standard errors.

[5] Including cross-sectional averages for all explanatory variables and allowing country-specific factor loadings on all these averages, which is the standard approach in the CCEP estimator of Pesaran (2006), was not possible. This led to an enormous increase in the number of parameters to be estimated and loss of degrees of freedom, affecting the efficiency of the estimator.

[6] Details are available from the authors upon simple request.

Table 1. Description of considered explanatory variables

Variable	*Definition*
TFP growth	yearly growth rate of TFP (in %)
working age population growth	yearly growth rate of population aged 15-64 (in %)
employment growth	yearly growth rate of employment (persons, in %)
old age dependency	population 65 and older in % of total population
young age dependency	population aged 0-14 in % of total population
life expectancy	life expectancy at birth at time t-20 (in years)
Gini index	Gini index for disposable income (scale 0-100 with 0 perfect equality)
inflation	yearly change of the GDP deflator (in %)
output gap	(actual output – potential output) / potential output (in %)
Short-term interest rate	3-month government T-bill rate (in %)
primary balance	primary balance of general government (in % of GDP)
public debt ratio	gross government debt (in % of GDP)
QE	public sector assets bought by the central bank (flow) in % of outstanding public debt
eurocrisis dummy	1 for euro area countries in years 2010-14
dummies related to other crises	1 in the specific crisis period (e.g. EMS crisis)
euro area membership	1 for euro area members

Note: For a description of data sources, see Appendix 1.

Unit root tests reveal a great deal of *non-stationarity* in many of the variables in our model. We ran country-specific ADF tests, the p-values of which we then used in an intersection test for panel unit roots as proposed by Hanck (2013). The test is robust to general patterns of cross-sectional dependence and yet straightforward to implement. Table 2 summarizes our results. We report both the number of countries (out of 17) in our sample for which the ADF test rejects the null hypothesis of nonstationarity at the 5% significance level, and the conclusion of the Hanck panel unit root test.[7] As to the explanatory variables in our model, the Hanck test cannot reject nonstationary for three demographic variables, the fiscal variables, inequality (Gini), and the short-term nominal interest rate.[8] By contrast, nonstationarity is strongly rejected for TFP growth, employment growth, inflation and the output gap. More caution seems needed in the interpretation of the results for $r - g$ and working age population growth. For these two variables the Hanck test rejects the unit root for the panel, despite that for at least 11 out of 17 countries (including the US, Germany and the UK), nonstationarity cannot be rejected. When we report our regression results and assess their quality in the next section, we will take this observation into account. Since the null of a unit root cannot be rejected for $r - g$ in so many countries, nor in several explanatory variables, we will also execute unit root tests on the residuals of our regressions. Meaningful results require stationary residuals.

[7] To determine the optimal number of lags for the ADF test we use the Akaike Information Criterion (AIC). The procedure of the Hanck panel test for a particular variable is as follows: we retrieve the p-values of the ADF test for all the cross-sections and arrange them in ascending order (= from most to least significant). Next, we compare $p_{(j)}$ with the critical point $j \cdot \alpha/n$ for each j with n denoting the number of series in the panel. The null hypothesis is rejected at level α if and only if $p_{(j)} \leq j \cdot \alpha/n$ for some $j \in \mathbb{N}_n$. In our sample $n = 17$. We report in Table 2 the test results imposing a value of 0.05 for α.

[8] For the first differences of all these variables nonstationarity is rejected.

Table 2. Unit root tests (1981-2018)

	Number of countries with p-value below 5% in the ADF test[1]	Hanck panel unit root test. Reject unit root?
$r - g$	6	yes
TFP growth	12	yes
Working age population growth	2	yes
Employment growth	12	yes
Old age dependency	0	no
Young age dependency	2	no
Life expectancy	0	no
Gini	2	no
Primary balance	5	no
Public debt ratio	1	no
Inflation	11	yes
Output gap	13	yes
Short-term interest rate	0	no

Note: 1. ADF test with drift. The number of lags has been determined using the AIC and may differ by country. The alternative BIC did not yield different results

3.3. Results

Tables 3, 4 and 5 contain our regression results. Table 3 includes the growth rate of total working age population as proxy for the variable n in growth theory. Tables 4 and 5 include the growth rate of employment.

Column (1) in Table 3 shows the results of a straightforward one-way fixed effects estimation, without accounting for the possible impact of unobserved common factors. Column (2) includes the cross-sectional average of $r - g$, but imposes the same coefficient on this variable for all 17 countries. From column (3) on, we allow a different coefficient for each country, and thus a different response to our proxy for the common factor(s). Column (4) leaves room to different effects from the fraction of younger versus the fraction of older retired individuals. The younger group includes all individuals with an age between 65 and 75, the older group all those older than 75. Column (5) allows for different effects of the public debt ratio depending on its level. We impose a threshold at 90%. Alternative estimations with different thresholds never led to econometrically better results. Last, this column also assesses the impact of public asset purchases (QE) by the central bank.

Our findings in the different columns of Table 3 are remarkably robust. We draw six conclusions. *First*, controlling for unobserved common factors slightly improves the R^2 of the regressions, while leaving the estimated coefficients for the observed explanatory variables generally unaffected. This conclusion also holds when we allow country-specific coefficients on the common factor in column (3). *Second*, for those variables that we have in common with existing studies, our results broadly confirm established findings. We also find that higher primary deficits (lower surpluses) and a higher public debt ratio raise $r - g$. The effects that we find are statistically highly significant, although they are a bit smaller in size than reported by Checherita-Westphal and Domingues Semeano (2020) in their study of $r - g$. They are also a bit smaller than the consensus estimates for the effects of the public debt ratio and the primary balance on r that we reported in Section 2. (This is not unexpected, though, since our

Table 3. Empirical analysis of $r - g$ (17 OECD countries, 1981-2018) [1]

	(1)	(2)	(3)	(4)	(5)
TFP growth	-1.056***	-0.956***	-0.949***	-0.956***	-0.943***
	(0.074)	(0.062)	(0.056)	(0.055)	(0.056)
Working age population growth	0.225	0.176	0.177	0.117	0.226
	(0.287)	(0.358)	(0.347)	(0.351)	(0.326)
Old age dependency	-0.080	0.004	0.040		
	(0.111)	(0.105)	(0.109)		
Old age dependency 65-75				-0.148	-0.124
				(0.123)	(0.121)
Old age dependency 75+				0.427**	0.412*
				(0.178)	(0.202)
Young age dependency	-0.055	0.064	0.104	0.068	0.063
	(0.079)	(0.082)	(0.093)	(0.085)	(0.091)
Life expectancy	-0.407***	-0.274**	-0.322***	-0.481***	-0.428***
	(0.116)	(0.123)	(0.119)	(0.131)	(0.135)
Gini	-0.233**	-0.343***	-0.347***	-0.312***	-0.307**
	(0.103)	(0.111)	(0.099)	(0.106)	(0.107)
Primary balance	-0.169***	-0.137***	-0.134***	-0.148***	-0.158***
	(0.040)	(0.038)	(0.032)	(0.032)	(0.030)
Public debt ratio	0.033***	0.027***	0.028***	0.027***	0.022**
	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)
Public debt ratio x Dummy90+					0.006*
					(0.003)
QE					-0.105**
					(0.043)
Inflation	-1.171***	-1.104***	-1.106***	-1.106***	-1.094***
	(0.055)	(0.054)	(0.053)	(0.049)	(0.050)
Output gap	-0.159***	-0.143***	-0.141***	-0.132***	-0.136***
	(0.041)	(0.038)	(0.041)	(0.040)	(0.038)
Short-term interest rate	0.478***	0.453***	0.431***	0.436***	0.445***
	(0.047)	(0.041)	(0.032)	(0.030)	(0.029)
Cross-sectional average *r-g*		0.270***	CS [2]	CS [2]	CS [2]
		(0.046)			
Observations	643	643	643	643	643
Country fixed effects	yes	yes	yes	yes	yes
Time fixed effects	no	no	no	no	no
R^2	0.83	0.85	0.86	0.86	0.86
R^2 adjusted	0.82	0.84	0.84	0.85	0.85
Cointegration [3]	yes	yes	yes	yes	yes

Notes : 1. Estimated and Driscoll-Kraay corrected standard errors in brackets. * p<0.1; ** p<0.05; *** p<0.01.
2. CS: the model has been estimated with country-specific coefficients on the cross-sectional average $r - g$.
3. yes: the Hanck (2013) test rejects the null of a unit root in the estimated residuals. Underlying country-specific ADF tests are with drift. The number of lags has been determined using the AIC and may differ by country.

interest rate r is an average of current and past rates). In line with many studies, we also observe a non-linearity, with the effect of public debt getting stronger above a debt ratio of 90%. From that level on, there may be an adverse effect on the sovereign risk premium in the interest rate or a reinforcement of negative growth effects from high debt. Furthermore, column (5) reveals a significant negative effect of central banks' public asset buying programmes, confirming the observation of Checherita-Westphal and Domingues Semeano (2020). *Third*, our results validate the favourable effects of inflation on $r - g$ and public debt dynamics. We observe a negative one-to-one relationship, which is not surprising since a higher growth rate of the GDP deflator feeds through directly in higher nominal GDP growth.[9] Obviously, if monetary authorities respond to higher inflation by raising short-term interest rates, this advantage will get smaller or disappear. Our estimates show a highly significant coefficient of about 0.45 on the short-term interest rate.

Our other conclusions are more innovative. They relate to the real long-run determinants that are at the center of our contribution. *Fourth*, in line with the findings of Lunsford (2017) and Lunsford and West (2019), faster technical progress and TFP growth raise overall economic growth much more than the interest rate, implying a significant decline in $r - g$. *Fifth*, as to the demographic variables, life expectancy is the only one with robust significant effects. In line with expectations that a longer life promotes savings, $r - g$ falls significantly in all five regressions in Table 3. Working age population growth and young age dependency always come out with small and statistically insignificant coefficients. Given the ambiguous theoretical effects of the first, and the lack of consensus in the literature regarding the latter, we should not be surprised about these two results. Given that we control for life expectancy, the absence of a significant (positive) effect on old-age dependency is harder to rationalize, at least at first sight. However, when we allow different effects for younger and older retirees in columns (4) and (5), more robust results arise. These seem to confirm the hypothesis and the findings of e.g. Kankaanranta (2019) that young retirees continue to save whereas it is mainly old retirees who dissave.

Last but not least, we obtain a highly significant negative coefficient on inequality (Gini) in all columns. This observation is fully in line with the hypothesis, and findings in the literature (see Section 2), that a more unequal income distribution raises aggregate savings and reduces the interest rate. If we accept this mechanism, our regressions allow no firm conclusions about the impact of inequality on growth. It can be positive or (mildly) negative. In the $r - g$ literature so far, the effect of inequality has been neglected.[10]

Following Checherita-Westphal and Domingues Semeano (2020), we added several dummy variables to the empirical model to capture the effects of specific crises (the EMS crisis in the early 1990s, the financial crisis in 2007-2008, the European sovereign debt crisis in 2010-2013) or institutional changes (euro area membership) that affected a group of countries simultaneously. Including these dummy variables made no noticeable difference for our results, however, when also other variables such as the output gap and the primary balance were included. Therefore, we do not maintain these dummy variables in further regressions.

[9] We tested whether this effect would become smaller over time. Including one, two or three periods lagged inflation, we expected to see a significant positive coefficient on these lagged terms. However, surprisingly, that was never the case.

[10] In Appendix 3 we report the effect of inequality on r and g separately. We obtain two negative effects. The one on r is much stronger and statistically significant. The one on g is weak and insignificant.

Table 4 takes column (5) of Table 3 as its starting point, but then adds employment growth as indicator for the variable n in growth theory. This specification, in column (6), explains a notably larger fraction of variation in $r - g$, as shown by the rise in the R^2. Employment growth obtains a significantly negative effect. Its contribution to economic growth proves stronger than its potential impact on the productivity of capital and the interest rate. For policy makers concerned about public debt dynamics, this is an important result. Column (7) confirms this result. In that column we replace employment growth and working age population growth by their difference, i.e. the growth rate of the employment rate. Their opposite coefficients, which are not significantly different in absolute value, justify this restriction. The estimated coefficients for the other explanatory variables in column (7) are hardly affected, except for the primary balance and the interaction term testing for a threshold effect on the level of the public debt ratio. The estimated coefficient on the former gets a lot smaller in absolute value.[11] The latter is now both statistically and economically insignificant.

The other three columns in Table 4 test the robustness of the estimation result in (7) by minor extensions of the set of explanatory variables and a change in the estimation method. Including time fixed effects in column (7b) or a lagged dependent variable in (7c) has no notable impact on the regression, except for the effect of QE. Time dummies may pick up its negative effect. Considering the possible endogeneity of some explanatory variables, we have also estimated the model using instrumental variables. Given the observation of cointegration in all regressions, and thus a stationary error term, there can be no correlation of any importance between this error term and the nonstationary explanatory variables. This conclusion does not hold, however, for those variables in Table 2 for which we rejected nonstationarity (a unit root). They were instrumented. Appendix 2 shows the list of instruments and the outcome of the corresponding Wald-tests of their significance in the first-stage regression. The results of the IV regression in column (8) occur highly robust for about all variables. The primary balance and QE keep their negative signs, but their effects are again statistically insignificant. The output gap is no longer significant at the 10% level.

Table 5 extends the set of explanatory variables in column (7) with one more determinant. Given the dominant impact of the US on financial markets and the business cycle in other OECD countries, it can be expected that the interest rate and growth in these other countries are affected by the behaviour of $r - g$ in the US. Columns (9a) and (9b) in Table 5 test this hypothesis. In (9a) we impose the same coefficient on all countries, whereas (9b) allows country-specific coefficients. This extension further increases the explanatory power of the regression. The common coefficient in column (9a) is statistically significant at the 10% level. When we allow country-specific coefficients in (9b), these are significant at the 5% level in the majority of countries.[12] The estimated coefficients on all other explanatory variables remain robust. The threshold dummy on the public debt ratio regains statistical significance in (9b). Only 'Old age dependency 75+' loses its statistical significance in (9b).

[11] Strong correlation (close to 0.55) between employment growth and the primary balance may explain this.

[12] Details are available upon request. Note that to be able to keep the US as one of the cross-sections in the panel, we also needed a relevant 'foreign' $r - g$ to explain the US data. We include the average of $r - g$ in Germany, the UK and Canada. It obtains a positive coefficient, which is also significant at the 5% level. Keeping the US in the panel is important. Only then, we can derive projections for the US. These are interesting in themselves, and they allow to account for the effect of future $(r - g)_{US}$ on the other countries according to column (9b) of Table 5.

Table 4. Empirical analysis of $r - g$ (17 OECD countries, 1981-2018) – part 2 [1]

	(5)	(6)	(7)	(7b)	(7c)	(8: IV) [5]
TFP growth	-0.943***	-0.929***	-0.927***	-0.929***	-0.961***	-0.847***
	(0.056)	(0.050)	(0.050)	(0.054)	(0.061)	(0.133)
Working age population growth	0.226	0.429*				
	(0.326)	(0.256)				
Employment growth		-0.598***				
		(0.040)				
Growth of the employment rate [2]			-0.592***	-0.541***	-0.522***	-0.711***
			(0.041)	(0.049)	(0.052)	(0.112)
Old age dependency 65-75	-0.124	-0.018	0.003	0.148	-0.002	-0.108
	(0.121)	(0.102)	(0.113)	(0.102)	(0.094)	(0.157)
Old age dependency 75+	0.412**	0.387**	0.396***	0.341**	0.367***	0.321**
	(0.202)	(0.151)	(0.146)	(0.140)	(0.127)	(0.142)
Young age dependency	0.063	-0.073	-0.070	-0.042	-0.007	-0.251*
	(0.091)	(0.056)	(0.056)	(0.059)	(0.059)	(0.158)
Life expectancy	-0.428***	-0.633***	-0.638***	-0.411**	-0.493***	-0.610***
	(0.135)	(0.112)	(0.111)	(0.184)	(0.108)	(0.128)
Gini	-0.307***	-0.247***	-0.247***	-0.183**	-0.239***	-0.283***
	(0.107)	(0.065)	(0.065)	(0.072)	(0.073)	(0.067)
Primary balance	-0.158***	-0.037	-0.043*	-0.055*	-0.021	-0.016
	(0.030)	(0.025)	(0.025)	(0.030)	(0.025)	(0.044)
Public debt ratio	0.022**	0.031***	0.032***	0.031***	0.024***	0.014**
	(0.009)	(0.008)	(0.007)	(0.008)	(0.006)	(0.006)
Public debt ratio x Dummy90+	0.006*	-0.00004	0.001	0.001	0.001	0.0004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
QE	-0.105**	-0.048*	-0.050**	0.022	-0.019	-0.010
	(0.043)	(0.025)	(0.025)	(0.041)	(0.023)	(0.025)
Inflation	-1.094***	-1.068***	-1.070***	-1.070***	-1.014***	-1.129***
	(0.050)	(0.042)	(0.041)	(0.045)	(0.044)	(0.162)
Output gap	-0.136***	-0.054**	-0.054**	-0.101***	-0.045*	-0.105
	(0.038)	(0.024)	(0.023)	(0.034)	(0.023)	(0.064)
Short-term interest rate	0.445***	0.393***	0.392***	0.366***	0.404***	0.402***
	(0.029)	(0.025)	(0.025)	(0.028)	(0.029)	(0.071)
One period lagged $r - g$					0.122***	
					(0.028)	
Cross-sectional average r-g [3]	CS	CS	CS	CS	CS	CS
Observations	643	643	643	643	641	594
Country fixed effects	yes	yes	yes	yes	yes	yes
Time fixed effects	no	no	no	yes	no	no
R^2	0.86	0.90	0.90	0.87	0.91	0.90
R^2 adjusted	0.85	0.89	0.89	0.85	0.90	0.89
Cointegration [4]	yes	yes	yes	yes	yes	yes

Notes : 1. Estimated and Driscoll-Kraay corrected standard errors in brackets. * p<0.1; ** p<0.05; *** p<0.01.
2. Difference between the growth rate of employment and the growth rate of working age population
3. CS: the model has been estimated with country-specific coefficients on the cross-sectional average $r - g$.
4. yes: the Hanck (2013) test rejects the null of a unit root in the estimated residuals. Underlying country-specific ADF tests are with drift. The number of lags has been determined using the AIC and may differ by country.
5. Instrumented variables: TFP growth, growth of the employment rate, output gap, and inflation. See main text and Appendix 2.

Table 5. Empirical analysis of $r-g$ (17 OECD countries, 1981-2018) – part 3 [1]

	(7)	(9a)	(9b)	(10) IV [5]	(11) $r_m - g$
TFP growth	-0.927***	-0.918***	-0.863***	-0.865***	-0.941***
	(0.050)	(0.052)	(0.055)	(0.137)	(0.064)
Growth of the employment rate [2]	-0.592***	-0.585***	-0.515***	-0.747***	-0.607***
	(0.041)	(0.039)	(0.037)	(0.077)	(0.068)
Old age dependency 65-75	0.003	0.015	0.016	0.046	-0.095
	(0.113)	(0.113)	(0.091)	(0.116)	(0.103)
Old age dependency 75+	0.396***	0.380**	0.131	0.378**	0.427***
	(0.146)	(0.150)	(0.150)	(0.162)	(0.145)
Young age dependency	-0.070	-0.073	-0.046	-0.036	0.134**
	(0.056)	(0.055)	(0.075)	(0.111)	(0.068)
Life expectancy	-0.638***	-0.610***	-0.483***	-0.585***	-0.296**
	(0.111)	(0.117)	(0.120)	(0.113)	(0.129)
Gini	-0.247***	-0.233***	-0.209***	-0.272***	-0.015
	(0.065)	(0.068)	(0.040)	(0.078)	(0.069)
Primary balance	-0.043*	-0.041	-0.078**	-0.010	-0.113***
	(0.025)	(0.025)	(0.031)	(0.007)	(0.036)
Public debt ratio	0.032***	0.032***	0.019***	0.010	0.026***
	(0.007)	(0.006)	(0.005)	(0.007)	(0.005)
Public debt ratio x Dummy90+	0.001	0.0005	0.005***	0.003	0.009***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
QE	-0.050**	-0.053**	-0.040**	-0.033*	-0.223***
	(0.025)	(0.027)	(0.020)	(0.017)	(0.053)
Inflation	-1.070***	-1.073***	-0.990***	-1.219***	-0.759***
	(0.041)	(0.041)	(0.039)	(0.137)	(0.043)
Output gap	-0.054**	-0.060**	-0.055**	-0.083	-0.201***
	(0.023)	(0.025)	(0.027)	(0.059)	(0.034)
Short-term interest rate	0.392***	0.384***	0.337***	0.377***	0.572***
	(0.025)	(0.025)	(0.029)	(0.060)	(0.043)
$(r-g)_{US}$		0.062*	CS [6]	CS [6]	CS [7]
		(0.036)			
Cross-sectional average *r-g* [3]	CS	CS	CS	CS	CS [7]
Observations	643	643	643	594	629
Country fixed effects	yes	yes	yes	yes	yes
Time fixed effects	no	no	no	no	no
R^2	0.90	0.90	0.93	0.92	0.91
R^2 adjusted	0.89	0.89	0.92	0.91	0.89
Cointegration [4]	yes	yes	yes	yes	yes

Notes : 1, 2, 3, 4, 5: see Table 4.

6: CS: the model has been estimated with country-specific coefficients on $r-g$ in the US. As relevant 'foreign' $r-g$ to explain the US data in the panel, we include the average of $r-g$ in Germany, the UK and Canada.

7: CS: the model has been estimated with country-specific coefficients on the cross-sectional average of $r_m - g$ and with country-specific coefficients on $r_m - g$ in the US. As relevant 'foreign' $r_m - g$ to explain the US data in the panel, we include the average of $r_m - g$ in Germany, the UK and Canada.

The results of the IV estimation in column (10) are highly similar to those of column (8) in Table 4. The only difference seems to be that 'Young age dependency' is again statistically insignificant, as in about all our earlier regressions. The primary balance, the threshold effect on public debt and the output gap have their expected signs, but in both IV regressions they are statistically insignificant.

Column (11) estimates our model with an alternative dependent variable. Instead of the implicit nominal interest rate r, we use the nominal market rate on 10-year government bonds (r_m) to compute the interest–growth difference. We can again conclude that our earlier findings are highly robust for most variables, both with respect to their estimated sign and their statistical significance. Only the Gini coefficient loses the significance that it had in all regressions reported so far. Furthermore, we observe (expected) changes in the size of some estimated coefficients, most likely due the fact that the market rate on new public debt will reflect changes in the drivers of the interest rate more and faster than the implicit interest rate on the outstanding stock of debt. The threshold effect of a high public debt ratio is stronger. The effect of public asset purchases by the central bank (QE) becomes more negative. Changes in the nominal short-term interest rate feed through stronger in r_m than in r. Last, the effect of inflation is now significantly lower than 1 in absolute value. Appendix 3 includes regressions for r, r_m and g as separate dependent variables.

Looking back at our main findings in Tables 3 to 5, we can now draw conclusions:

- From growth theory we learn that technical progress and employed population growth are key determinants of both the interest rate and the economic growth rate. Empirically, the effect on g is clearly stronger. Growth promoting policies that target TFP or employment growth may imply higher r, but their net effect on $r - g$ is clearly and robustly negative.
- Demographic change does affect $r - g$, although not all variables matter. We find no robust significant effects (neither statistically, nor economically) when the fraction of children or the fraction of young retirees (age 65 – 75) rises at the expense of the fraction of people at working age. For given life expectancy, however, a rising proportion of old retirees (75+) does imply a significant increase of $r - g$ in most of our regressions. Whereas young retirees do not seem to save significantly less than people at working age, old retirees do. Only old retirees seem to dissave as predicted by lifecycle theory. Last but not least, all our results show a strong and very significant negative effect on $r - g$ from rising life expectancy. This finding is fully in line with the results of calibrated OLG models studying the effects of demographic change, but it has been neglected by earlier empirical work studying $r - g$.
- We obtain a highly significant negative coefficient on inequality (Gini) in all regressions explaining $r - g$. This observation is in line with findings in the literature that a more unequal income distribution raises aggregate savings and reduces the interest rate. Also this effect has been neglected by earlier empirical work on the interest – growth difference.
- All our regressions confirm that a rise in the public debt ratio does imply a higher $r - g$. In most regressions, we also find that public asset purchases by the central bank reduce $r - g$. Our findings for the impact of changes in the primary balance, and for the existence of a threshold effect when public debt exceeds 90% of GDP, are less robust. The primary balance obtains the expected negative coefficient, but that coefficient is smaller than in existing literature and not always significant. We learn from our regressions that as soon as we control for employment growth, the primary balance loses a lot of its explanatory power. Public debt above 90% of GDP tends to raise $r - g$ more than below 90%, but this

difference is statistically significant in less than half of our regressions.
- Due to its direct effect on nominal GDP growth and its very slow impact on the implicit nominal interest rate, higher inflation has a robust favourable impact on public debt dynamics. If monetary policy makers respond to higher inflation by raising the short-term interest rate, this favourable impact will decline.

4. Projections

4.1. Underlying assumptions

Having estimated the impact of the long-term drivers of the interest–growth difference, we are now able to make projections for $r - g$ for the next two decades. For these projections we make use of forecasts from the IMF World Economic Outlook (October 2021) and the OECD Demography and Population databases (December 2021).

For the demographic variables, OECD projections are directly available until 2040 (and beyond). For five other determinants (inflation, the output gap, the short-term interest rate, the government's primary balance and the ratio of public debt to GDP), the IMF provides forecasts until 2026 which we will use. *For later years*, we have to make our own assumptions. More precisely,

- Inflation is assumed equal to the 2% objective of most central banks;
- The output gap is set equal to zero;
- Starting from IMF forecasts until 2026, our projections for the future short-term interest rate are computed in accordance with expectations theory of the yield curve and the observed 10- and 20-year government bond yields at the end of February 2022.[13]
- The choice that we make about the evolution of the primary balance is more delicate. Our prior or baseline assumption is that the primary balance in percent of GDP remains constant at the level of the IMF forecast for 2026. For many countries this implies 'permanent' primary deficits, varying from about 0.15% in Italy to 1.9% in the UK, 2.8% in France, 3% in the US, and even 4.2% in Belgium. For other countries, such as Germany and Sweden, IMF forecasts put forward a slight primary surplus in 2026.
  An alternative second assumption that we will introduce, is a zero primary balance from 2027 in all countries.
- The future evolution of the public debt ratio is computed endogenously applying the debt dynamics equation to the produced projections for $r - g$ and the imposed primary balance.

For four determinants of $r - g$, our imposed projections are subject to more uncertainty. Our approach here is to start from rather *conservative* assumptions about the future values of these determinants, i.e. assumptions that would rather bias projections for $r - g$ upward than downward.[14]

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[13] For the euro area countries, this choice implies the possibility of different projected future short-term rates, even if they share the same central bank. Countries with a higher long-term interest rate in February 2022, will have a higher projected future short rate. In this way, our projections for the short rate will not only incorporate the overall rise in long-term government bond yields between autumn 2021 and February 2022, but also the cross-country differences in risk premia that existed at the end of February 2022. We consider this an advantage.

[14] Another illustration of our rather conservative approach is our use of the IMF projections (WEO) of October 2021 for inflation until 2026. To the extent that these projections do (did) not capture the strong rise of inflation since autumn 2021, our assumptions regarding the level of inflation in the near future may be too low. Given the negative effect of inflation on $r - g$, our estimates for the latter may be too high.

- First, as to growth of the employment rate, forecasts are available from the IMF and the OECD until 2023. For later years we conservatively impose a constant employment rate (despite policies in many countries aiming at higher employment to cope with the pressure imposed by ageing on the welfare state).

- Second, existing predictions concerning TFP growth are mixed. Rachel and Smith (2017) expect rates to slow down in the coming years. Feyer (2007) and Aiyar et al. (2016) find a negative impact of demographic change and ageing on technical progress. Others, however, are explicitly positive about TFP growth in the future. Techno-optimists like for example Mokyr (2014) have long emphasized the advantages to be expected from progress in areas such as computing, artificial intelligence, robotics, medicine, new materials, genetic engineering, etc. More recent developments may reinforce this positive expectation. McKinsey Global Institute (2021) and the Economist (2020), for example, point to firm and household responses to the covid-19 pandemic that accelerate the adoption of new technologies and that may contribute to faster productivity growth. The Economist (2021) emphasizes growing optimism about the potential of new technologies as one explanation for the impressive pace of investment in the aftermath of the covid recession. By contrast, Arriola et al. (2020) highlight possible negative effects of the pandemic on efficiency and TFP following a re-localisation of global value chains. As a cautious input for our projections, we rely on the forecasts for future TFP growth reported by the OECD (2021) in its baseline "long view" scenario for the world economy until 2060. Compared to the earlier version in OECD (2018), we observe that the OECD revised its projected TFP growth downward for most countries. Our choice to impose the revised data is consistent with the chosen conservative approach in our own projections.

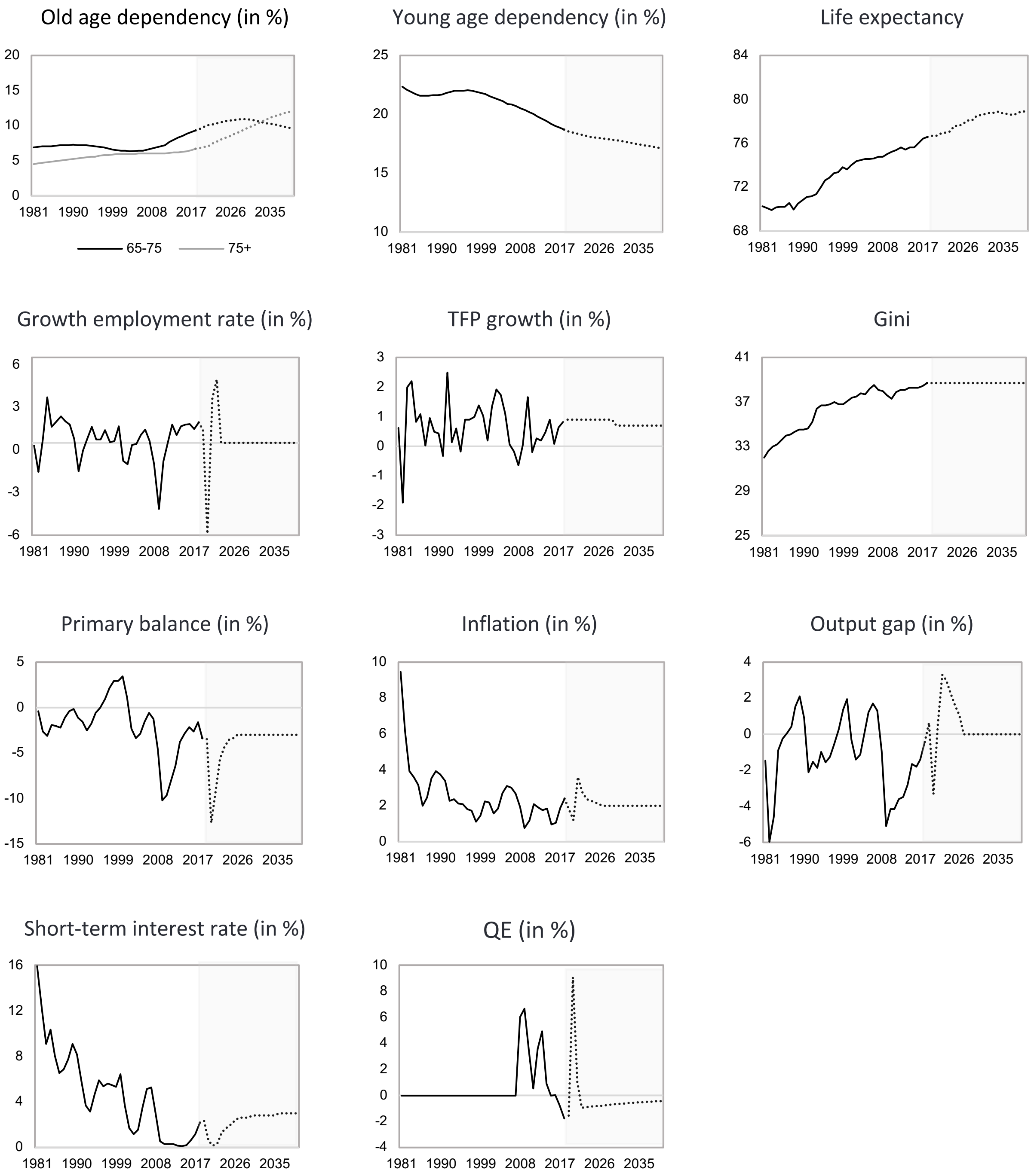
- The same ambiguity in predictions exists for the Gini coefficient. After decades of rising inequality in most countries, there are arguments leading to an expected further rise as well as arguments indicating a fall of inequality. Often the former arguments emphasize the adverse impact of innovation (e.g. Law et al., 2020) or demographic change and accelerating automation (e.g. Prettner and Bloom, 2020; Acemoglu and Restrepo, 2021; Prettner and Strulik, 2021; Jacobs and Heylen, 2021). The latter arguments highlight the role that policy may play in response to the increased sensitivity to inequality in society during the last decade (see e.g. Blanchard and Rodrik, 2019; Clark et al., 2021). In our conservative approach we assume inequality to remain constant for the coming 20 years.

- Last but not least, we assume that central banks stop buying government bonds as of 2022. More than that, we impose that all assets bought since the financial crisis should be sold or redeemed gradually by 2040. Every year from 2022 to 2040 there is a reduction of one 19th of the nominal stock of public assets at the end of 2021.

For illustrative purposes, Figures 2a and 2b show the historical values and our projections for the future path of the determinants of $r - g$ in the US, Germany and France. Similar data are collected for all countries in our sample. In addition to the variables shown, we remember from Table 5 that every country's $r - g$ depends also on the evolution of its public ratio and on the evolution of $r - g$ in the US. These two variables are endogenously determined by the model.[15] The cross-sectional average of $r - g$, which we included in our empirical model to capture the impact of unobserved common factors, is set equal to zero from 2019 on.

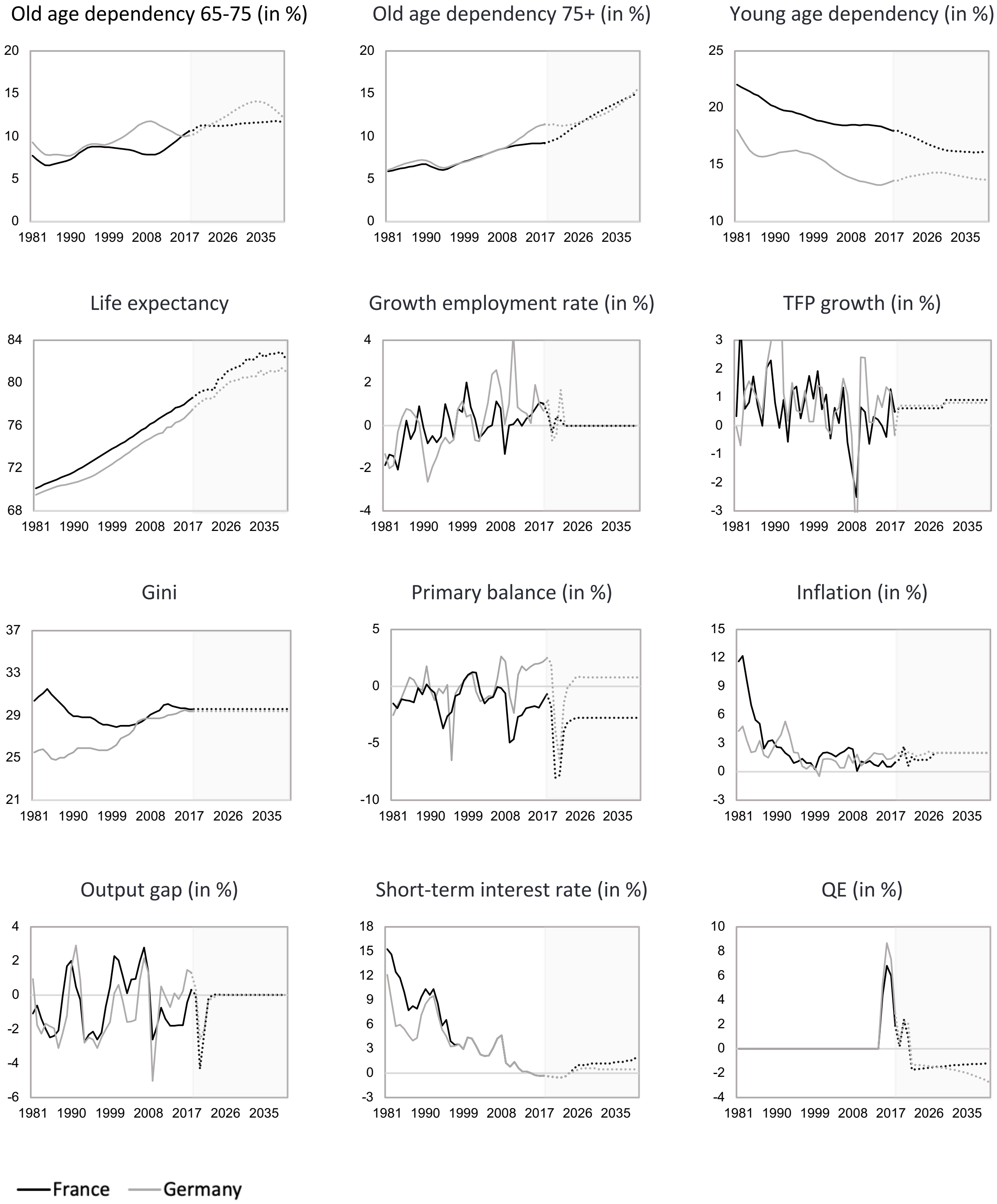
[15] By analogy, $r - g$ in the US depends on the average of $r - g$ in Germany, the UK and Canada. See footnote 12. This average is also endogenous.

Figure 2a. Historical values and baseline assumptions concerning the determinants of $r - g$ in the US.



Sources and motivation: see main text. In addition to the variables shown here, also the evolution of public debt in the US and the evolution of the average of $r - g$ in Germany, the UK and Canada matter for the behaviour of $r - g$ in the US (see footnote 12 and note 6 below Table 5). Both are determined endogenously by our estimated model. The cross-sectional average of $r - g$, which we included in our empirical model to capture the impact of unobserved common factors, is set equal to 0 from 2019 on.

Figure 2b. Historical values and baseline assumptions concerning the determinants of $r - g$ in France and Germany.



Sources and motivation: see main text. In addition to the variables shown here, also the evolution of their public debt and the evolution of $r - g$ in the US matter for the behaviour of $r - g$ in France and Germany. These variablers are determined endogenously by our estimated model. The cross-sectional average of $r - g$, which we included in our empirical model to capture the impact of unobserved common factors, is set equal to 0 from 2019 on.

4.2. Projections

Figure 3 reports our projections for the US, the UK, Germany, France and Belgium, using the estimation result reported in column (9b) of Table 5.[16] The full line in the shaded area in the graphs on the left depicts for each country our baseline projection for $r - g$ when we assume that the IMF forecast of the primary balance in 2026 applies also to later years. For the US, the UK, Belgium and France, that means persistent deficits. The interrupted line shows our projection assuming a zero primary balance after 2026 in the country concerned (while maintaining the IMF forecast for the other countries). The graphs on the right show the induced evolution of the public debt ratio. Projections for $r - g$ in all other countries in our sample are shown in Appendix 4. We draw three conclusions.

First, for each individual country our empirical model described by column (9b) explains a very large fraction of the variation in the data for $r - g$ in 1981-2018. For the countries included in Figure 3 the R^2 always exceeds 0.8.

Second, we observe a clear difference between the US and the UK on the one hand, and most European countries on the other. In the European group, $r - g$ is projected to remain negative for the next two decades. This is also the case in our baseline projection for Belgium and France.[17] Exceptions to this general result are the highly indebted countries in Southern Europe, in particular Italy and Greece (see Appendix 4). In other words, in most European countries public debt will be sustainable even with a primary deficit. Under the assumption of a zero primary balance after 2026, the graphs on the right of Figure 3 reveal a rapid decline of the public debt ratio in Germany, France and also Belgium. Reality is different for the US and the UK. For the US our baseline projection of $r - g$ in the next two decades is positive. For the UK it is close to zero. If, alternatively, a zero primary balance is assumed in these two countries after 2026, the projection for $r - g$ is a little lower. Even then, however, the US may not be able to bring down its public debt ratio. The UK may only be able to do this at a very slow pace.

Third, when we look at the underlying determinants of these differences between the US and the considered European countries, a higher initial public debt ratio and a slower increase in life expectancy in the US are indisputable factors. Another factor may be our assumption about future TFP growth, following OECD (2021). With an annual rate of only 0.7%, projected TFP growth in the US in 2030-60 remains below projections for all other countries (except Canada) as well as below actual TFP growth in the US in earlier decades.

4.3. Discussion and contribution to the debate on public debt targets and sustainability

Our finding that $r - g$ remains negative in most OECD countries, especially in Europe, during the next two decades is important. It also offers empirical support for the baseline $r - g$ scenario put forward by the OECD (2021, p. 23) and for the medium-term expectations of the ESM (2021). The fact that our projections are based on a number of rather conservative assumptions, strengthens our result. For example, TFP growth may be higher than we imposed. Moreover, in contrast to our assumption of zero growth in the employment rate, governments can do a lot to promote employment (see e.g. OECD, 2021). From our results we know that both changes would make $r - g$ even more negative. In addition, effective employment policies would also reduce primary expenditures, including pension expenditures, when people work longer and retire later.

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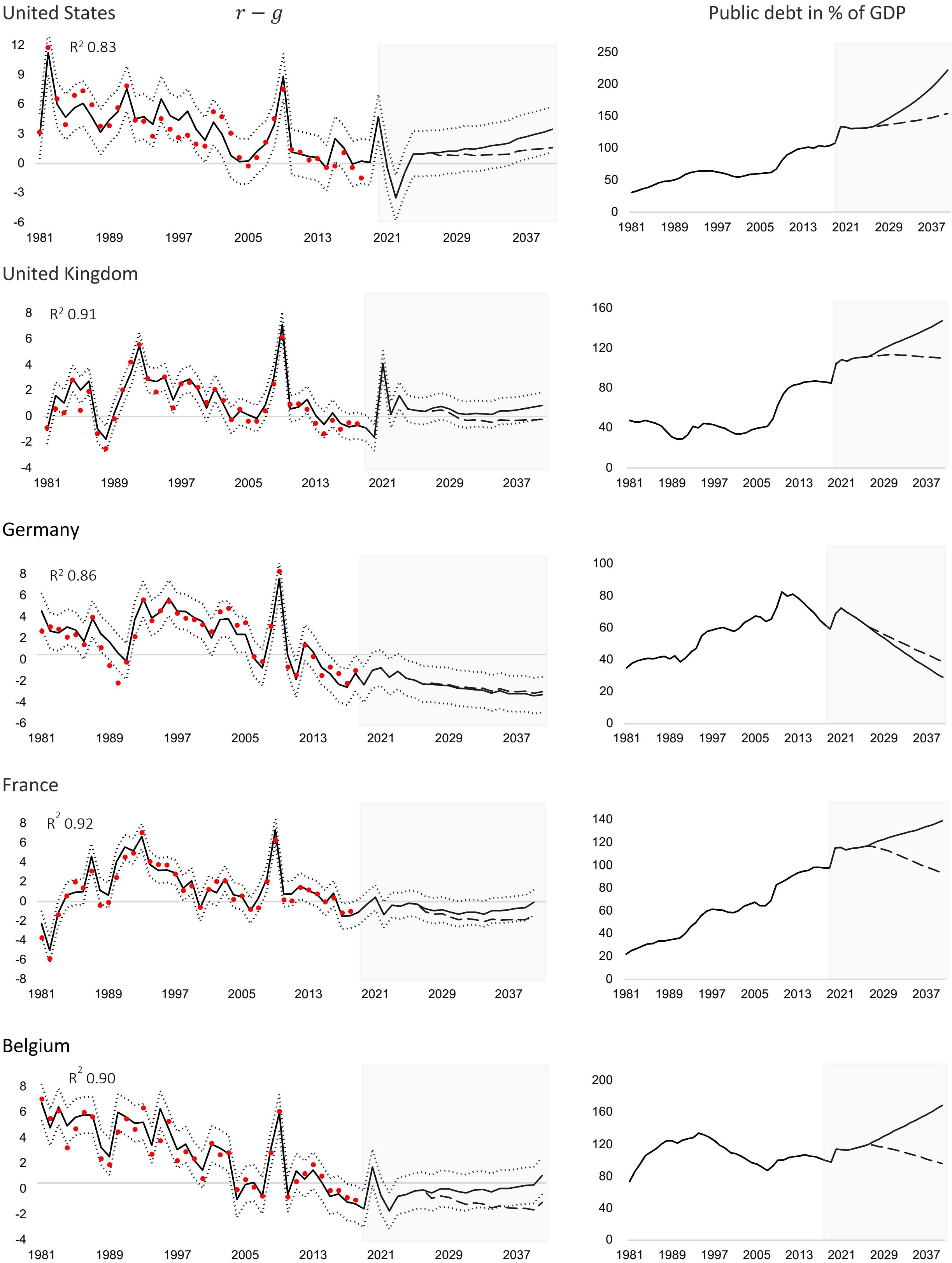
[16] Of all countries in our sample, Belgium is expected by the IMF to have the highest primary deficit in 2026.

[17] In Germany, Austria, the Netherlands, Ireland, Sweden and (almost so) Finland, even the whole confidence band is below zero (see also Appendix 4).

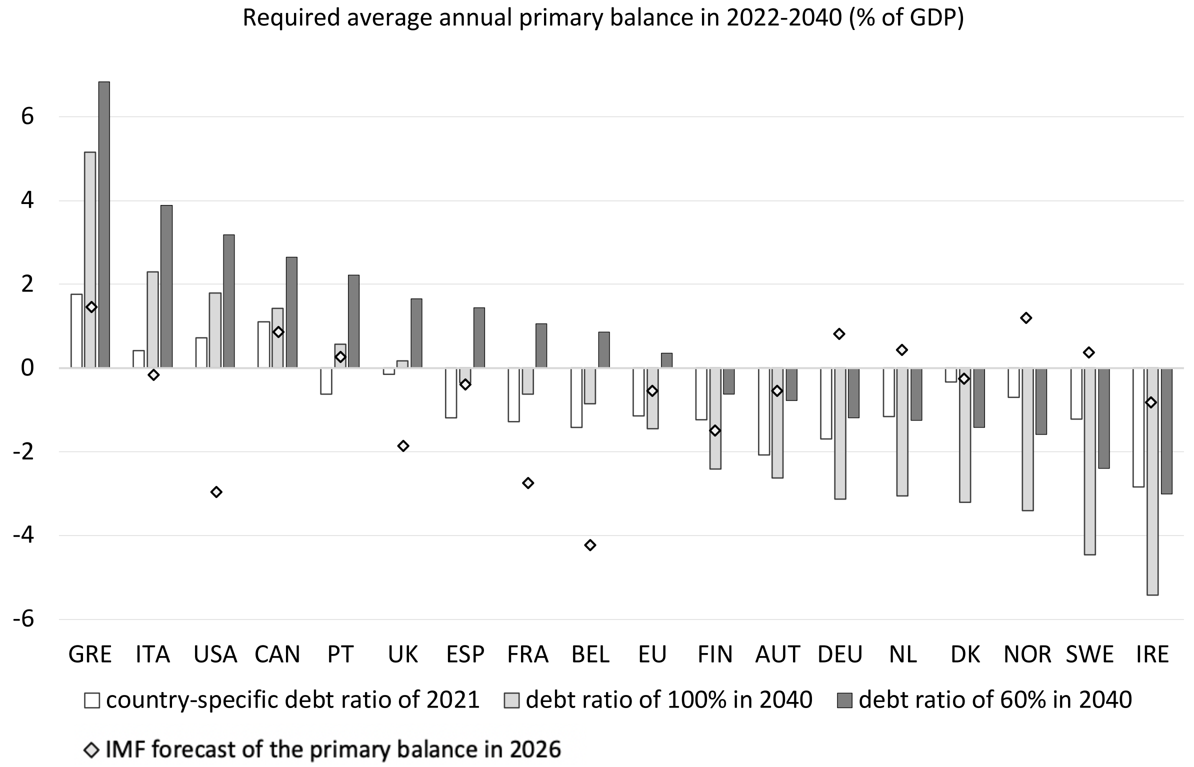
Figure 3. Predicted vs observed values of $r - g$ and the implied public debt ratio (% of GDP)



Notes: In each figure on the left, the red dots indicate the observed $r - g$ (data), while the full line displays the predicted $r - g$ using the regression result in column 9(b) in Table 5. The dotted lines indicate the 95% confidence band around the prediction. The R^2 in each figure indicates the fraction of the observed variation in $r - g$ in that country that is explained by the empirical model.

From 2019 on, the full line shows our baseline projection for $r - g$ using the same regression result 9(b) and the projection for the determinants of $r - g$ as described in Section 4.1. The interrupted line is the projection for $r - g$ assuming a zero primary balance from 2027 in the country concerned (not in the other countries). The figure on the right shows the evolution of the public debt ratio that follows endogenously from the debt dynamics equation, the projected series for $r - g$, and the related two assumptions for the primary balance after 2026.

Figure 4. Required primary balance to reach a chosen target for the public debt ratio



With $r < g$, governments can afford to run permanent primary deficits and yet have their debt ratio converge to a stable equilibrium level. The lower $r - g$, the higher the public debt ratio that governments can sustain, or the higher the primary deficit that accords with a chosen debt ratio.[18] Figure 4 reports the average primary balances that countries must deliver in 2022-2040 to achieve three alternative targets for the public debt ratio. A strength of our approach is that the results internalize the endogenous effects on $r - g$ of alternative levels of the primary balance and alternative debt paths according to the regression outcome in column (9b). In addition to data for 17 individual countries, we also report the weighted average of all 13 EU countries in our sample. The three imposed debt targets are (i) to keep the country's public debt ratio constant at its level of 2021, (ii) to reach a debt ratio of 100% by 2040, and (iii) to reach a debt ratio of 60% by 2040. The 100% target is a central element in the proposed future fiscal rules for the EU by authors of the European Stability Mechanism (ESM, 2021). The 60% target is part of the proposal by the European Fiscal Board (EFB, 2020). Other authors argue against the enforcement of uniform numerical criteria (e.g. Blanchard et al., 2021; Martin et al., 2021).

Figure 4 reveals huge differences, both between countries and between the required primary balances to achieve the three different targets.

As to the individual countries, it is clear that imposing uniform debt targets will require very different fiscal stances. Whereas the required primary balances to consolidate the public debt ratio of 2021 vary broadly between +2% and -2%, the range of outcomes increases to about 10%-points when either a target of 60% or 100% is imposed. For the US, Canada, Greece

[18] See footnote 1.

and Italy, the achievement of any of the three assumed debt targets will require primary surpluses during the next two decades. By contrast, in the majority of European countries the achievement of at least two of these targets is consistent with primary deficits. This is not a new result, it matches our earlier observation that the expected $r - g$ is negative in most countries, but not in the US, Italy or Greece. Although this is good news for fiscal policy makers in most countries, there are also clear reasons for caution. First of all, in some European countries, current IMF (2021) expectations of primary balances in 2026 are still below the required levels, with Belgium and France the most outspoken examples. Second, in all countries, managing the required primary balance (or the allowed primary deficit) may remain challenging if one accounts for the expected increase of expenditures due to ageing and the rising price of services in the next decades. OECD (2021) estimates these additional expenditures at about 5% of GDP between 2021 and 2060 in the median country. To this can be added the growing need for governments to invest in climate policy.

Figure 4 also reveals huge differences between the overall outcomes of the different targets. Seeing the results, it is clear that requiring all European (or euro area) countries to converge to the current 60% target, is rather unrealistic. It would require immediate fiscal consolidation in a majority of countries (and on average in the EU), which could threaten the recovery from the covid-19 recession. Moreover, as also argued by ESM (2021), it would go against the need for higher investment and the greening of the European economies. To the extent that this undermines potential growth, or raises future expenditures to cope with the consequences of climate change, it also undermines the feasibility of the required path to 60%. Making the adjustment period longer may ease the requirement of immediate and/or extensive fiscal consolidation in several countries, but it does not change the (high) number of countries that would have to adopt a restrictive fiscal stance. One advantage of a higher common target (e.g. 100%) is that it gives more room for public investment and reduces the number of countries with a restrictive stance. Another is that it matches better the structural reality of a negative $r - g$ in many countries and the implied higher debt-bearing capability of European governments. The world is fundamentally different than in the 1990s when Europe fixed the 60% debt target.

5. Conclusions and policy implications

The sustainability of public debt and optimal fiscal governance depend crucially on the difference between the implicit nominal interest rate on outstanding debt and the growth rate of nominal GDP. This paper studies the drivers of this difference econometrically in a panel of 17 OECD countries since 1981. In line with existing literature, we include fiscal, monetary and financial determinants of $r - g$. We also control for the impact of unobserved common factors and for the influence of changes in $r - g$ in the United States on the other countries. Our paper distinguishes itself from existing empirical literature by its focus on the real long-run drivers of $r - g$ such as technical progress, employment growth, components of demographic change, and income inequality. We find robust results for the effect of determinants about which existing evidence was mixed or lacking. More precisely, we observe robust negative effects on $r - g$ from faster technical progress, higher employment growth, rising life expectancy and rising inequality. A rising proportion of old retirees (75+) in the population implies an increase in $r - g$. By contrast, an increase in the fraction of children or the fraction of young retirees (age 65 – 75) at the expense of the fraction of people at working age, has no significant effect on $r - g$.

As to other determinants, we confirm a number of established findings. We also observe a significant positive effect on $r - g$ when the ratio of public debt to GDP rises, or when the central bank raises the short-term interest rate. Furthermore, we find that asset purchases by the central bank and higher inflation imply a significantly lower $r - g$ in all (or almost all) our regressions. Last, we do observe a negative effect from the government's primary balance and a positive threshold effect from higher public debt when debt exceeds 90% of GDP, but these effects are often statistically insignificant.

The second part of the paper shows our projections for $r - g$ until 2040. Our results suggest that $r - g$ remains negative for the next two decades in most countries of the European Union that we study, with Italy and Greece as notable exceptions. In that way we provide empirically based support for the expectations regarding $r - g$ as formulated by authors of the European Stability Mechanism (ESM, 2021) and for the assumed path of $r - g$ by the OECD (2021). By contrast, for the US and the UK our projections of $r - g$ until 2040 are positive and virtually zero, respectively.

Our projections are inevitably subject to some uncertainty. We emphasize, however, that they are based on panel regressions that explain over 80% of variation in the data in 1981-2018 in almost all considered individual countries. Moreover, they have been derived under assumptions about the future path of the determinants of the interest–growth difference that would rather bias projections for $r - g$ upward than downward. We assumed moderate future rates of technical progress, constant employment rates, quantitative tightening by central banks from 2023 on, and constant inequality. Ample literature, however, supports faster technical progress than we assumed, and rising instead of constant inequality. Starting from that literature would imply a lower $r - g$ than we now project. Successful employment policies would have the same implication. Even if recent changes in long-term nominal interest rates show an upward path, the message from fundamental drivers related to demography, technical progress, employment, and inequality, may for many countries still be one of low interest rates and negative $r - g$.

Our results have important implications for future policy and fiscal governance in Europe. *First*, a negative $r - g$ enables governments to run a primary deficit without debt necessarily rising in percent of GDP. With a high primary deficit, the public debt ratio will rise, but eventually converge to a constant equilibrium level. In times of a great need for public investment and a greening of the economy, this offers a unique opportunity. *Second*, our results show the pertinence of the ongoing discussion in Europe about the 'optimal' level of the debt to GDP ratio. Considering that the current and expected interest–growth difference is much lower than in previous decades, the capacity of governments to carry debt is substantially higher than in the past. In that respect, our results support an increase in the public debt target in Europe, for example from 60% to 100% as advocated by authors from the European Stability Mechanism (ESM, 2021). A 100% rule would give more room for public investment and reduce the number of countries forced into a restrictive fiscal stance from 2023. If a debt objective of 60% were to be achieved by 2040, our results suggest that the weighted average primary balance in the EU countries in our sample should be positive over the period 2022-2040. Other authors (e.g. Blanchard et al., 2021; Martin et al., 2021) advocate a more radical change to give up uniform numerical criteria. Their argument is not inconsistent with our results, but will be even harder to decide politically. *Third*, policy matters, also outside the narrower fiscal domain. Although faster technical progress and higher employment raise both the growth rate and the interest rate, the favourable effect on growth is much stronger.

As a result, $r - g$ will fall. An additional advantage of policies to raise employment and growth, is that they will also improve the primary balance.

To answer the main question raised in this paper, most Europeans should worry less about public debt. This does not eliminate, however, reasons for caution when interpreting our results. For some countries, today's expectations of the future primary deficit are still (much) higher than consistent with achieving a 100% objective for the public debt ratio by 2040. Moreover, in all countries rising costs related to ageing (see e.g. OECD, 2021) and climate adaptation will make it harder to achieve the allowed primary deficit, or the required primary surplus. Higher primary deficits do not imply an explosive public debt. But the higher the equilibrium debt level, the more vulnerable the fiscal situation will be to future bad shocks that may push the interest rate above the growth rate. In our analysis we have accounted for endogenous interest rate changes due to standard crowding out effects, but not for possible changes in the risk premium that are much harder to model. A structurally negative $r - g$ creates important opportunities and makes life easier for fiscal policy makers, but does not exempt them from the task to strongly monitor their expenditures, balances and debt.

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Appendix 1: Data description and sources

Gross government debt in percent of GDP

Source: OECD Economic Outlook No. 109 (series GGFLMQ). Data before 1995 has been obtained by extrapolation with data from EU Commission (AMECO) and IMF (WEO and Historical Public Debt database). Data for the USA have been taken from FRED.

Gross general government interest payments in percent of GDP

Source: OECD Economic Outlook No. 109 (series GGITNP and GDP). Missing data for Germany, Greece and Ireland have been obtained by extrapolation with data from the World Bank.

Implicit nominal interest rate r

Computed for year t as gross government interest payments in year t divided by the government debt in year t-1, i.e. r(t) = GGITNP(t)/(GGFLMQ(t-1)*GDP(t-1))

Gross domestic product, nominal value, growth

Source: OECD Economic Outlook No. 109 (series GDP_ANNPCT)

Output gap in percent of potential GDP

Source: OECD Economic Outlook No. 109 (series GAP). Missing data for Germany, Greece and Ireland, and data for the years before 1985, has been obtained by extrapolation from IMF (WEO) data.

Primary balance as a percentage of GDP

Source: OECD Economic Outlook No. 109 (series NLGXQ). Missing data for Germany, Greece and Ireland have been obtained by extrapolation with data from IMF (Public Finances in Modern History).

Inflation (*GDP market prices, deflator, growth)*

Source: OECD Economic Outlook No. 109 (series PGDP_ANNPCT). Missing data for Germany and Greece have been obtained by extrapolation with data from IMF (WEO). The data for the year 1991 for Germany has been taken from ECB.

Short-term interest rate

Source: OECD Economic Outlook No. 109 (series IRS). Missing data for Germany, Greece, Ireland and Sweden in the 1980s and early 1990s has been obtained by extrapolation with data from EU Commission (AMECO).

The Gini Index, disposable income

Source: Solt (2020), SWIID version 9.1 (series gini_disp)

Life expectancy at birth in years

Source: The World Bank (series SP.DYN.LE00.IN)

Growth of TFP at constant national prices

Source : Penn World Tables 10.0 (series rtfpna)

Working age population growth (growth of population aged 15-64)

Source: The World Bank (series SP.POP.1564.TO.ZS)

Employment growth

Source: OECD economic outlook No. 109 (series ET_ANNPCT). Missing data for Germany, Greece and Ireland are extrapolated with data taken from Penn World Tables (series emp).

Growth of the employment rate

Computed as the difference between employment growth and working age population growth

Population of ages 65 and above, percent of total population

Source: The World Bank (series SP.POP.65UP.TO.ZS)

Population of ages 0-14, percent of total population

Source: The World Bank (series SP.POP.0014.TO.ZS)

QE: Quantitative easing

Computed as public sector assets bought by the central bank in year t (flow) as a percentage of outstanding public debt in t

Source: Databases of the central banks of the countries in our sample.

Appendix 2: Instrumental variables

For the four endogenous explanatory variables in equation (1), which are vulnerable to possible correlation with the error term in the regressions, we suggest the instruments displayed in Table 6. We then conduct a regression of each of these four endogenous variables on all exogenous variables from equation (1) and the entire list of proposed instruments. This so-called first stage regression is subsequently used to execute Wald tests of instrument significance, with outcomes presented in Table 7. All Wald tests yield F-statistics that exceed Staiger and Stock's (1997) rule of thumb value of 10.

Table 6. List of possible instruments for the endogenous variables.

Variable	*Suggested instruments*
TFP growth	TFP growth (t-2) TFP growth (t-3) Output gap (t-2) Output gap (t-3)
Growth of the employment rate	Growth of the employment rate (t-2) Growth of the employment rate (t-3) Labor tax rate (t) [1] Labor tax rate (t-1) Oil price (t) [2] Oil price (t-1)
Inflation	Inflation (t-2) Inflation (t-3) Short-term interest rate (t-1) Short-term interest rate (t-2)
Output gap	Output gap from advanced economies (t) Output gap from advanced economies (t-1)

Notes: 1. The labor tax rate was calculated as (compensation rate/wage rate) – 1.
2. The oil price refers to the USD price per barrel of spot brent oil.
Data sources for these instruments: OECD Economic Outlook No. 109 (series WSST, WRT, WPBRENT)

Table 7. Wald tests of instrument significance.

Regression	**F-statistic Wald test**
Regression (7d)	
TFP growth	13,52
Growth of the employment rate	21,19
Inflation	29,18
Output gap	33,96
Regression (9d)	
TFP growth	13,02
Growth of the employment rate	20,44
Inflation	23,69
Output gap	29,66

References

Staiger, D. & Stock, J.H. (1997). Instrumental variables regression with weak instruments. *Econometrica*, *65*, 557-586.

Appendix 3: Empirical analysis of r, r_m and g as single dependent variables (17 OECD countries, 1981-2018) [1]

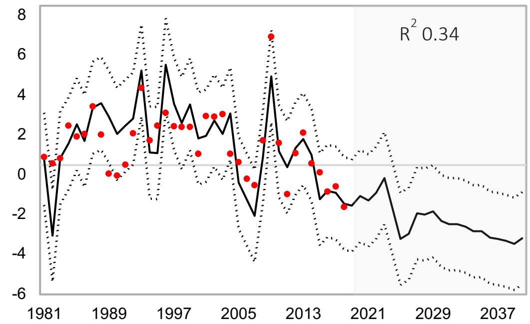
	r	r_m	g
TFP growth	0.023	0.037	0.971***
	(0.020)	(0.024)	(0.042)
Growth of the employment rate	0.004	-0.026	0.575***
	(0.020)	(0.053)	(0.025)
Old age dependency 65-75	-0.104**	-0.242***	-0.170**
	(0.039)	(0.083)	(0.066)
Old age dependency 75+	-0.303**	-0.048	-0.248***
	(0.131)	(0.111)	(0.082)
Young age dependency	-0.002	0.015	-0.114*
	(0.040)	(0.079)	(0.063)
Life expectancy	-0.220**	-0.045	-0.030
	(0.106)	(0.109)	(0.072)
Gini	-0.138***	-0.063	-0.010
	(0.053)	(0.058)	(0.054)
Primary balance	-0.003	-0.036	0.052**
	(0.015)	(0.022)	(0.022)
Public debt ratio	0.007	0.014***	-0.002
	(0.005)	(0.005)	(0.004)
Public debt ratio x Dummy90+	0.001	0.007***	-0.007***
	(0.001)	(0.002)	(0.001)
QE	0.001	-0.125***	0.083***
	(0.010)	(0.032)	(0.019)
Inflation	0.031	0.120***	1.023***
	(0.025)	(0.033)	(0.028)
Output gap	-0.002	-0.115***	0.094***
	(0.025)	(0.032)	(0.020)
Short-term interest rate	0.134***	0.451***	-0.046***
	(0.027)	(0.054)	(0.013)
$(r, g, r_m)_{US}$ [2]	CS	CS	CS
Cross-sectional average [2]	CS	CS	CS
Observations	643	643	643
Country fixed effects	Yes	Yes	Yes
Time fixed effects	No	No	No
R^2	0.95	0.96	0.98
R^2 adjusted	0.95	0.95	0.97
Cointegration	yes	yes	yes

Notes: 1. Estimated and Driscoll-Kraay corrected standard errors in brackets. * p<0.1; ** p<0.05; *** p<0.01.
2. CS: the model has been estimated with country-specific coefficients on the cross-sectional average of r, r_m and g and with country-specific coefficients on r, r_m and g in the US. As relevant 'foreign' variables to explain the US data in the panel, we include the average of r, r_m and g respectively in Germany, the UK and Canada.

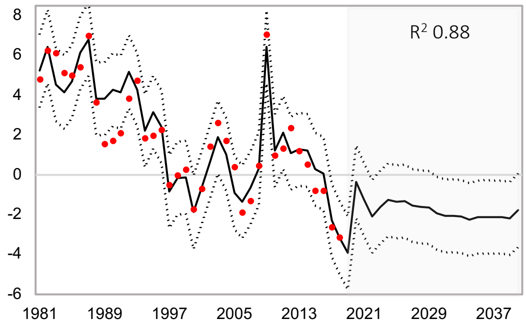
Appendix 4: Basic projections for other OECD countries

Central and Northern Europe

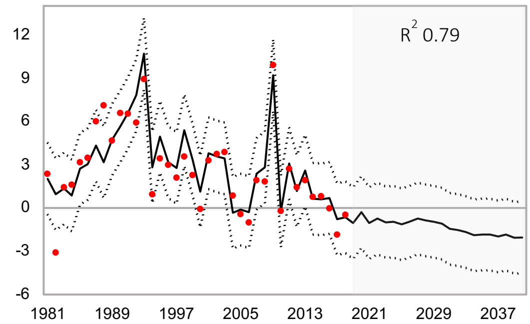
Austria



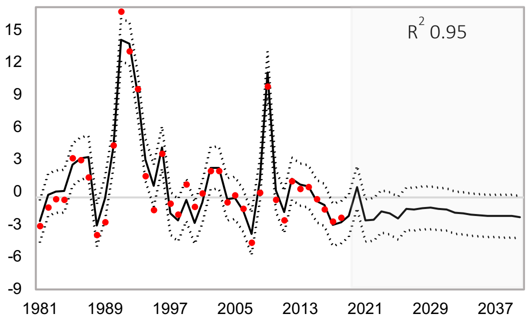
The Netherlands



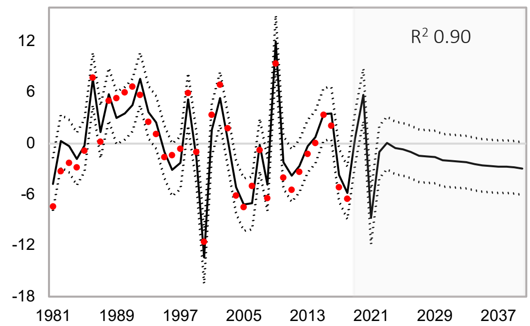
Denmark



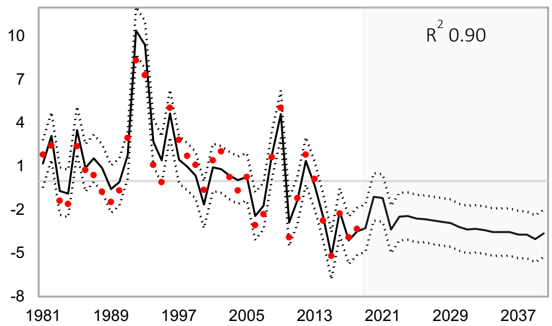
Finland



Norway

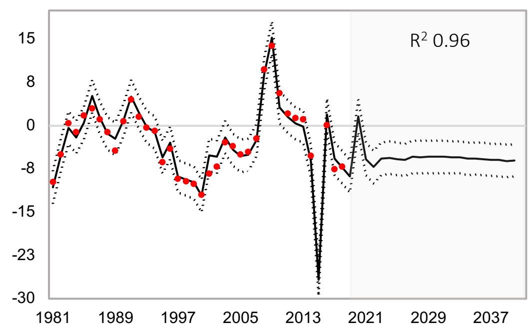


Sweden

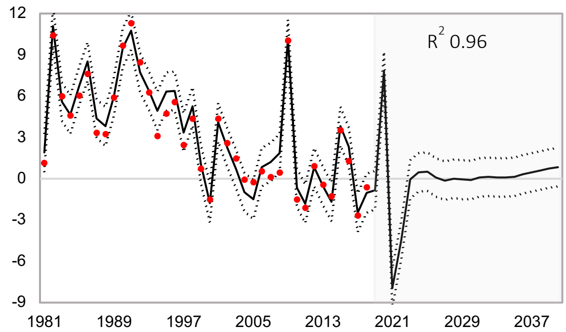


Anglo-Saxon countries

Ireland

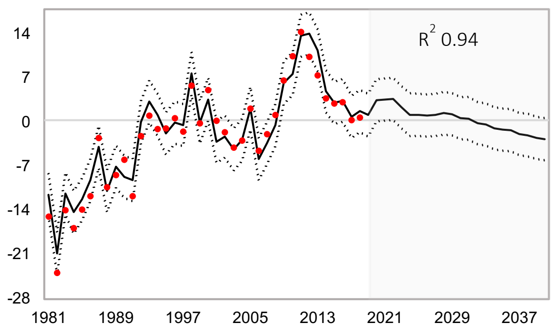


Canada

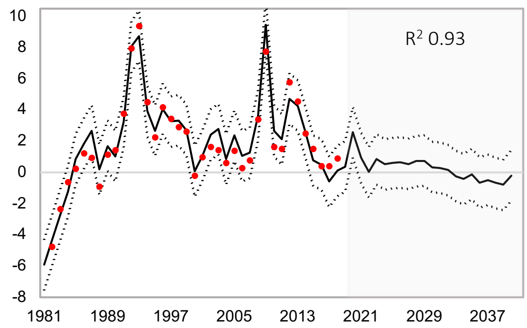


Southern Europe

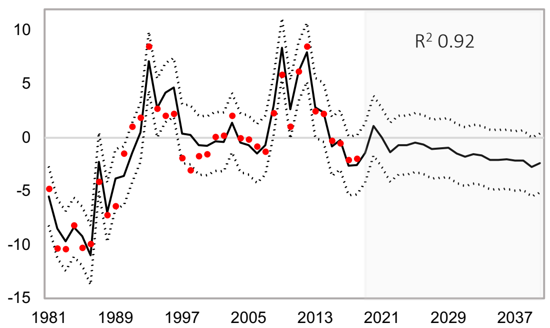
Greece



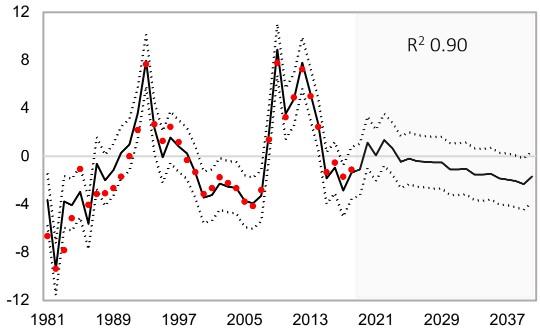
Italy



Portugal



Spain



Note: In each graph, the red dots indicate the observed $r - g$ (data), while the full line displays the predicted $r - g$ using the regression result in column 9(b) in Table 5. The dotted lines indicate the 95% confidence band around the prediction. The R^2 in each graph indicates the fraction of the observed variation in $r - g$ in that country that is explained by the empirical model.
From 2019 on the full line shows our baseline projections for $r - g$ using the same regression result 9(b) and the projection for the explanatory variables as described in the beginning of Section 4.1. The primary balance in percent of GDP is assumed constant after 2026 (constant at the level of the IMF forecast for 2026).