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Cristina Checherita-Westphal,
João Domingues Semeano

Interest rate-growth differentials on government debt: an empirical investigation for the euro area

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Abstract

The interest rate-growth differential $(i - g)$ is an important determinant of government debt dynamics and sovereign sustainability analysis. A persistently negative differential could in principle enable lowering debt ratios even in the absence of primary surpluses. Many advanced economies, including in the euro area, had recently - before the COVID 19-crisis hit - exhibited a strong negative inertia in their $i - g$. But to which extent can this be sustained? The focus of our analysis is on the mature euro area economies over the EMU period and the decades before, when the differential was mostly positive on average. We use panel econometric techniques to identify the determinants of $i - g$ across euro area countries and then employ a panel BVAR model to forecast $i - g$, while providing various sensitivity analyses. We conclude that the differential is likely to remain negative after the COVID 19-crisis and well below its long-term average for most euro area countries, but several factors will likely push it up. This would warrant caution in the conduct of fiscal policy over the medium term for the high debt countries, where $i - g$ is higher on average and the probability of positive values over the medium term is non-negligible. Finally, the on-going crisis, whose duration and economic effects are hard to predict, brings an unprecedented level of uncertainty for both the short and long-run dynamics of the differential.

Keywords: fiscal sustainability; government debt; interest rates; interest-rate-growth differential, income catch-up

JEL classification: E43; E62; H63; H68; G1.

Non-technical summary

The difference between the average (implicit) interest rate that governments pay on their debt and the (nominal) growth rate of the economy, the so-called interest rate-growth differential $(i - g)$, is a key variable for debt dynamics and sovereign sustainability analysis. While generally assumed to be positive over the longer-run, at least in advanced, mature economies, it had turned negative for most of the euro area (EA) countries over the recent years, before the Corona virus (COVID-19) crisis hit, and, based on latest available market expectations, it is forecasted to remain so over an extended period. A sustained negative differential would allow governments to stabilise or reduce their debt ratio even in the presence of budget deficits.

This paper contributes to the empirical literature by providing a thorough investigation of the topic of interest rate-growth differential on government debt across euro area countries. First, we focus on the more homogenous sample of mature euro area economies, while comparing the results with other samples. We also analyse the relevant EMU period and the decades since mid-1980s, that is, the historical periods more closely comparable with the current economic structures and policy conditions (apart from the current crisis). Second, we test for a large range of possible determinants of the differential, with emphasis on fiscal and monetary variables. Finally, we provide forecasts for the interest rate-growth differential with panel BVAR models and a sensitivity analysis with other country-specific forecasts.

To start with, we provide stylised facts for the interest rate-growth differential before the COVID-19 crisis. The long-term historical averages since the early 1980s or the EMU period are positive in most high income, mature economies and hover around 1 percentage point. Each of the components of the differential has followed a protracted downward trend, as highlighted by recent discussions on secular stagnation and declining equilibrium interest rates. Real interest rates in advanced economies have declined since the 1980s and, in the wake of the global financial crisis, plummeted to exceptionally low levels. At its turn, real and potential output growth has also dropped. The average cross-country differential on government debt has, however, followed a less pronounced decline and showed no apparent trend until more recently.

We then investigate the determinants of $i - g$ across euro area countries. We find that countries with a higher public debt burden, higher primary deficits or an increase in public debt are more likely to have a higher interest rate-growth differential (even after controlling for the position in the economic cycle). The differential tends to increase significantly and to add quickly to the public debt burden in bad economic times, as was the case in the financial, economic and sovereign debt crisis post-2007 (and reflected even more sharply in the current COVID-19 crisis). For the euro area period, monetary policy loosening is associated with a lower differential. Equivalently, a monetary policy tightening, proxied by an increase in the short-term interest rate or other monetary policy rates or a decline in monetary policy assets, would induce an increase in the interest rate-growth differential on government debt. On the other hand, technological progress or any other factors that increase TFP growth promote a decrease in $i - g$.

The impact of ageing is more difficult to disentangle. A higher dependency ratio is found to be associated with lower $i - g$, while slower population growth tends to increase the differential. This result could be justified in so far as ageing induces predominantly a higher saving−lower interest rate configuration, while lower population growth may have a more pronounced and quicker effect on growth.

As to the impact of other variables, there is some evidence that the global saving glut hypothesis is associated not only with a decline in interest rates, but also in the interest rate-growth differential. With respect to various time events, after controlling for the relevant macroeconomic and financial variables, the one-off introduction of the euro seems to have promoted some decline in the interest-rate growth differential mainly stemming from the reduction in the implicit interest rate. Regarding the effect of the financial and sovereign debt crisis, the post-crisis dummy (after 2007) is found positive and statistically significant. That is, the interest rate-growth differential since the financial crisis has been higher, on average, than before (1985-2007). However, controlling for other relevant factors, including the fiscal position and monetary policy responses, the post-crisis differential has actually been statistically significantly *lower* than before. Trends in the differential are also explained by common external factors, with $i - g$ in the US being positively correlated with $i - g$ across the euro area countries.

Finally, based on this empirical analysis, we employ a panel BVAR model to forecast $i - g$ and we provide a sensitivity analysis with a country-specific deterministic DSA model (as in Bouabdallah, Checherita-Westphal et al., 2017). We show results across three consecutive forecast vintages based on the European Commission (EC) Ameco datasets. We start with the EC autumn 2018 forecast vintage (based on the historical period 1999-2017 used in the empirical analysis), continue with the 2019 autumn vintage and finally show results using the EC spring 2020 forecast, which include the projected impact of the Corona crisis. All models considered forecast median $i - g$ that are generally negative in five years, but in most cases increasing over the forecast horizon. Most importantly, for the high debt countries, the forecasts point to higher differentials compared to the low debt countries and a non-negligible probability of positive $i - g$ values.

The forecasts should be regarded with caution, especially in light of the high uncertainty related to the effects of the COVID-19 crisis. Overall, while $i - g$ is projected to remain below its historical average according to these models, several factors advise caution in the conduct of fiscal policy over the medium term in the high debt euro area countries. In general, as emphasised by other authors, relying on $i < g$ as a substitute for reforms is a risky proposition.

I. Introduction

The difference between the average (implicit) interest rate that governments pay on their debt and the (nominal) growth rate of the economy, the so-called interest rate-growth differential $(i - g)$, is a key variable for debt dynamics and sovereign sustainability analysis.

In practice, debt sustainability analysis typically sets out from the simple debt accumulation equation:

$$\Delta b_t = \left(\frac{i_t - g_t}{1+g_t}\right) b_{t-1} - pb_t + dda_t \quad (1)$$

which provides for a simple accounting framework to decompose the change in the government gross debt-to-GDP ratio (Δb_t) into its key drivers, consisting of: (i) the "snowball effect", i.e. the impact from the difference between the average nominal interest rate charged on government debt (i_t) and the nominal GDP growth rate (g_t) multiplied by the debt-to-GDP ratio in the previous period (b_{t-1}); (ii) the primary budget balance ratio (pb_t); and (iii) the deficit-debt adjustment as a share of GDP (dda_t) or the stock-flow adjustment, comprising factors that affect debt but are not included in the budget balance (such as acquisitions or sales of financial assets, valuation effects, etc.). With $dda = 0$, the debt ratio will stabilise when $pb_t \approx (i_t - g_t)b_{t-1}$. Thus, if $i > g$, as it has been commonly assumed, a primary surplus is needed to stop the debt ratio from rising and an ever larger surplus is needed to reduce it. That primary surplus will need to be larger, the higher the initial debt level. Conversely, a persistently negative $i - g$ differential on government debt ($i < g$), would imply that debt ratios could be reduced even in the presence of primary budget deficits (lower than the snowball effect). Moreover, assuming that the differential would not depend on the level of indebtedness, governments would have incentives to issue even more debt as this would pay for itself with a "snowball" rolling just downhill.

While generally assumed to be positive over the longer-run, at least as it was the case in advanced, mature economies, on average, since the 1980s and/or in the absence of financial repression, it had turned negative for most of the euro area (EA) countries over the recent years, before the Corona virus (COVID-19) crisis hit, and, based on latest available market expectations and forecasts, it may remain so over an extended period.

The objective of this paper and its contribution to the empirical literature on the topic is to investigate the trends and determinants of the interest rate-growth differential for the mature euro area economies (EA-12).[1] As first members of the Economic and Monetary Union, this group of high income, advanced countries is more homogeneous than the larger (OECD/advanced economies) samples investigated so far. Particularly over the euro area period, with a common monetary policy, cross country differences in terms of institutions and policies, are easier to control for (or less prone to omitted variable bias) than in larger samples. Moreover, we are also interested in any potential

[1] We focus on the EA-12 sample, which includes the first 12 members of the euro area: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherlands and Portugal.

differences between the determinants of $i - g$ in this group and other advanced economies, and expand our analysis to larger samples. Second, we analyse the historical periods more closely comparable with the recent macroeconomic and policy conditions, that is, the relevant EMU period and the decades before since mid-1980s. Third, we test for a large range of possible determinants of the differential, with emphasis on fiscal and monetary variables. Finally, we provide forecasts for the interest rate-growth differential with panel BVAR models and a sensitivity analysis with other country specific forecasts.

According to the European Commission's (EC) autumn 2018 forecast, all euro area countries except Italy had negative $i - g$ in 2017, situation expected to be maintained in 2020, the end of the forecast horizon at the time. By 2020, $i - g$ was projected to increase in 12 countries and decrease further in the remaining 7 euro area countries, including some of the largest economies. The simple average of the estimated change for the EA countries over 2017-2020 was +0.37 percentage points (*pp*). In the recent Spring 2020 forecast, historical data showed a more pronounced increase in the differential over 2017-19 than previously projected in many countries. For instance, in Germany, the differential was projected to decline from -2.1 in 2017 to -2.4 percentage points (pp) in 2019, while the most recent data show an increase from -2.0 to -1.4 *pp* (still way below the long-term average of 1.1 *pp* over 1999-2017). In Italy, the differential was projected to decline from 0.9 in 2017 to 0.5 *pp* in 2019, with the latest data showing a strong increase from (a downwardly revised level in 2017 of) 0.5 to 1.3 *pp* in 2019. The fully unexpected COVID-19 crisis has brought a surge in the differential for 2020, with record positive, albeit temporary, levels for all countries, the highest being projected for Spain, Greece and Italy (above 11 *pp* according to the EC spring 2020 forecast).

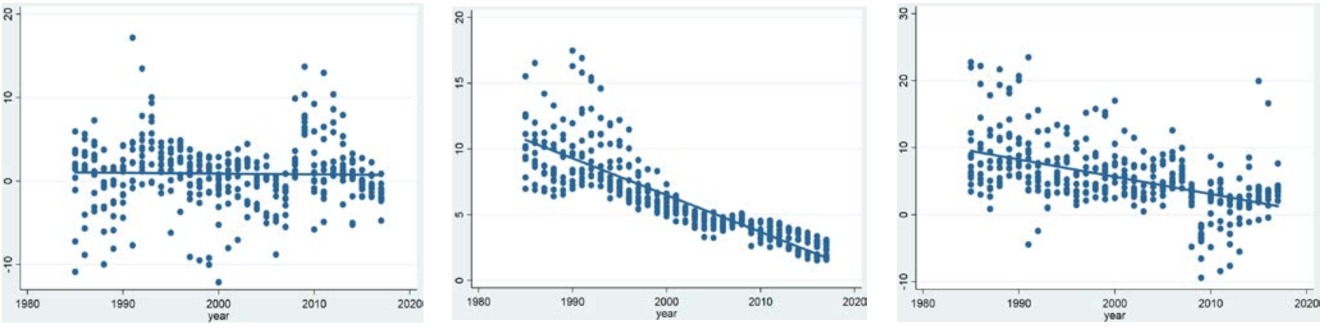
A debate on the role of fiscal policy with a persistently negative interest rate-growth differential was revived by O. Blanchard in his 2019 AEA Presidential address. Using the US example, Blanchard (2019) makes the point that the costs of government debt may be smaller than generally assumed in the policy discussion. This is because the (US) safe interest rate (a proxy of marginal bond rates) is below the nominal GDP growth rate and this is more the historical norm rather than the exception. With a negative $i - g$, public debt may have no fiscal cost. It may still have welfare costs, but these may also be lower than typically assumed. An implication of this proposition would be that the US can sustain high(er) debts without significant costs. The author stressed, however, that the purpose of his lecture was not to argue for higher debt *per se*, but to allow for a richer discussion of debt policy and appropriate debt rules than is currently the case.

A recent IMF paper (Mauro and Zhou, 2020) documents that, contrary to the usual assumption, negative differentials have occurred more often than not in both advanced and emerging economies over a long period spanning up to 200 years. Yet, while for the full sample of advanced economies, the central tendency indicators (both median and mean) are negative, for the longest period covered in the sample (before WWII) and for the most recent period (post-1980s), they are positive. It is mainly the post-WWII period and the high inflation years in the 70s that drives the results. Moreover, for many euro area countries the picture is more balanced in terms of prevalence of negative differentials.[2] Finally, the paper asks the question whether "one can sleep more soundly" with such negative (automatic debt reduction) differentials. The answer the authors give is "not really": in fact, governments tended to loosen fiscal positions and accumulate more debt over the period and low differentials are not found to be associated with lower frequency of sovereign defaults.

In our paper, we start by noting that the average interest rate-growth differential over the EMU period and periods since 1985 has been positive for most EA-12 countries and other advanced economies. For many of these countries, the differential hoovers around 1 pp, on average. In the EA-12 sample, only Ireland and Luxembourg recorded negative average differentials over the period 1985-2017. See Appendix 1 for detailed data by country. In general, in the context of recent discussions on secular stagnation, and for the euro area countries in particular, each of the components of the differential has followed a protracted downward trend, while the trend in the differential is not that clear (Chart 1).[3]

Chart 1: Interest rate-growth differential across EA-12 over 1985-2017

Interest rate growth differential ($\boldsymbol{i-g}$) | **Implicit interest rate ($\boldsymbol{i}$)** | **Nominal GDP growth ($\boldsymbol{g}$)**



Notes: own calculations based mainly on the European Commissions' Ameco dataset (vintage EC Autumn 2018 forecast). EA-12 comprises Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherlands and Portugal (see also footnote 2). Extreme outliers for growth for Ireland in 2015 and 2016 as a result of statistical reevaluations are excluded in these charts and throughout the analysis in this paper.

Since the 1980s in particular, real interest rates in advanced economies have declined and, in the wake of the global financial crisis, plummeted to exceptionally low levels. At its turn, this decline has been linked, inter alia, to a decline in potential output. The question thus remains about the trend in the difference between the two variables and, specifically, about the differential for the government sector, as opposed to the economy at large. Finally, as suggested by Chart 2 below (and the analysis in

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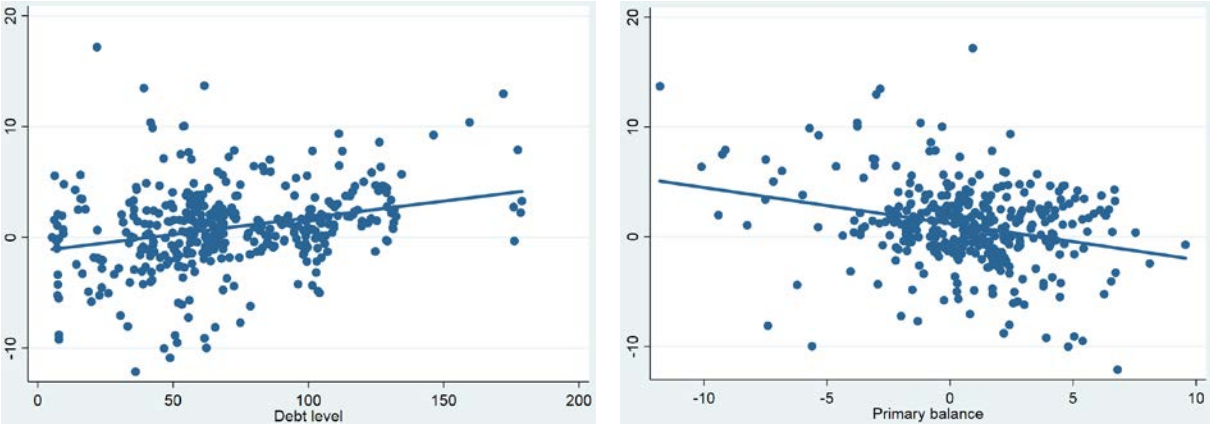
[2] The sample of advanced economies in the paper includes 24 countries, out of which 11 euro area countries (broadly, the currently matured economies considered in our paper). For the whole sample of advanced economies over 1800-2018, the mean share of years with a negative differential is found at 61%, but Belgium and Germany have shares below 50% and most of other euro area countries hover around 50-58%. Portugal and Spain are at the mean with 61% and only Greece and Ireland are above. The outlier of the sample is South Korea, with a share of negative i-g values close to the emerging economy sample's at 97%.

[3] However, if the period is extended to 1970, the trend in $i-g$ is increasing given deeply negative differentials in the 70s, a period of very high inflation and thus nominal growth, which had not been fully reflected in the nominal bond yields. For the period since 1970, despite the still declining trend in the implicit interest rate, the nominal growth trend was on a more strongly declining path on account of tampering inflationary pressures. See Appendix 1 for a similar chart and more stylised facts on $i-g$.

section 2), higher government debt and primary deficit levels seem to be associated with higher interest rate-growth differentials.

Chart 2: Interest rate-growth differential, public debt level and primary balance across EA-12 over 1985-2017



Notes: own calculations based mainly on the European Commissions' Ameco dataset (see also notes for Chart 1). For the purpose of this chart's display, in panel b, two extreme outliers of primary deficits (larger than 27% of GDP) for Ireland in 2010 and Slovakia in 1993 are excluded. Extreme outliers for growth for Ireland in 2015 and 2016 as a result of statistical reevaluations are excluded in these charts and throughout the analysis in this paper.

The paper is structured as follows. We first review the theoretical and empirical literature on the topic. We then use panel econometric techniques to identify the relevant determinants of $i - g$ across euro area countries and, finally, employ a panel BVAR model to forecast $i - g$ and provide sensitivity analyses with other country-specific forecasts. In appendices, we provide a descriptive analysis of the trends in interest growth-rate differential with a focus on euro area countries, as well as other robustness checks and data source information.

II. Literature review

Theoretical models do not provide clear cut conclusions with respect to the sign and size of the interest rate-growth differential on government debt. In general, models are grounded on the assumption that the inter-temporal budget constraint holds, that is, the present value of future primary surpluses should equal the current level of debt (no explosive debt paths). While standard growth theory implies positive $i - g$, in overlapping generation models (OLG) with non-diversifiable uncertainty or models with rational bubbles, a negative $i - g$ on government debt could co-exist with a dynamically efficient economy.

Most models under the standard economic growth theory suggest that the interest rate-growth differential for the economy as a whole (in the neoclassical growth model), as well as for the government (in endogenous growth models), should be positive in economies that operate at their steady-state.[4] This is a result of the so-called "modified golden rule" and follows from the basic

[4] See also conclusions in Escolano (2010) and Escolano et al. (2017).

features of a competitive equilibrium, which ultimately requires that the return on investment (the interest rate) be higher than the rate of increase of the capital stock (which equals the GDP growth rate along the balanced growth path). This differential is needed to compensate for the fact that the economic agent gives up consumption today, has a positive discount rate of the future and needs to cover the depreciation of capital stock. For a derivation, see Appendix 2.

Though rather challenged more recently after the great recession and the euro area sovereign debt crisis,[5] a balanced growth path is thought to describe well the medium-term macroeconomic growth features of advanced economies.[6]

Piketty (2014) work also revolves around the so-called *fundamental inequality*[7] in market economies (advanced countries at the world technological frontier), namely $r > g$ (here, both sides of the inequality in real terms). The point of the book is that r is much larger than g over extended periods of time (r in the order of 5-6% vs. 1-1.5% potential growth in most developed countries). However, r is in the book considered to be the average annual rate of return on capital for the economy as a whole, mostly referred to as the return on *private* capital. Moreover, the "rate of return" on capital is considered as a "much broader notion than the rate of interest" *(p. 52).* The book also notes that the average long-run rates of return can vary between 3-4% for bonds and 7-8 for stock, while "the real rate of interest on public debt[8] is sometimes much lower" (*p*.53). Several other studies (see in Teulings and Baldwin, ed. (2014) also find the (rather puzzling result) that the return on private capital has remained remarkably stable, especially in the aftermath of the recent great recession, while the (natural) rate of interest has followed a persistently downward trend.

On the other hand, some OLG models with non-diversifiable uncertainty (see Blanchard 2019) or models with rational bubbles (see Martin and Ventura, 2017 for a review) allow for $r < g$ to co-exist with competitive equilibria.[9] In an OLG model without uncertainty or frictions (Diamond, 1965), the interest rate equals the marginal return on capital. The equilibrium in this model can be dynamically inefficient whenever the steady-state interest rate lies below the growth rate of the economy (the

[5] Summers (2014) notes the apparent difficulty that industrial economies are having in achieving financially stable growth with full employment after the crisis. He goes on in positing that a decline in the natural rate of interest, coupled with low inflation, could indefinitely prevent the attainment of full employment. Moreover, other results of the standard growth model, in particular the convergence of the interest rate across the sectors in the economy and its equality with the marginal product of capital in equilibrium, are not fully supported by the data and remain empirical puzzles. For instance, the divergence between public versus private rate of interest is seen as an "arbitrage condition puzzle" in finance, as any such risk premium should be ultimately extinguished in equilibrium.

[6] As pointed out in Escolano (2010), standard economic growth theory is largely silent about the *i-g* values that should be expected for economies in transition to balanced growth, other than predicting that over the long term these economies will converge toward this path.

[7] This inequality is posited as a fundamental factor behind income inequality, implying that wealth accumulated in the past grows more rapidly than wages and income, allowing holders of capital to accumulate even more wealth and be better off relative to holders of labour (only).

[8] In (indirect) relation to the subject of our paper, it is worthwhile mentioning that Piketty (2014) does not necessarily support a redistribution of wealth through public debt. He makes the point that with a long string of financial and economic crises and large scale public debt repudiations, "many dangerous illusions have arisen in regard to government debt and its relation to social distribution".

[9] At the same time, in most of such models, the government is assumed to borrow at the "safe rate", while accounting for sovereign credit risk or possibility of default would raise the cost of public debt. For a summary of this literature, see D'Erasmo, Mendoza et al. (2016).

capital stock is excessive and its return is too low). The presence of non-diversifiable uncertainty creates a wedge between the risk free rate (R_F, associated in these studies with the interest rate on *safe* government debt) and the marginal product of capital (MPK), so that $R_F < g < MPK$ can be compatible with a dynamically efficient economy. In models with rational bubbles, in which the interest rate is below the growth rate, an economy can still be dynamically efficient, as the bubbles can enhance liquidity in the presence of severe constraints or even reallocate resources more productively (Martin and Ventura, 2012).

Another string of literature, albeit not directly dealing with the question of the differential, seeks to investigate the decline in interest rates in advanced economies, in particular in the so-called "natural rate of interest", the risk-free equilibrium rate consistent with output being at potential and with stable prices (for a review see, inter alia, Brand et al., 2018). In this context, the "new" secular stagnation literature – see Summers (2014), and Teulings and Baldwin, ed. (2014) for a review – makes the point that both the (natural) real rate of interest (of the economy as a whole and on government debt), as well as the potential growth rate have declined significantly in advanced economies. Which effect dominates is not directly investigated. In the most commonly used OLG models, ageing is one of the most important factors found to generate a decline in both the natural rate of interest and the output growth (see ECB, 2018 for a review). In an OLG model of secular stagnation, Eggertsson et al. (2017) posit that demographics (lower fertility and mortality rate) and productivity factors (lower productivity growth) could explain most of the decline in the natural rate of interest in the US (matching the decline in real Federal Funds rate between 1970 and 2015), while the increase in the US government debt was the main counterbalancing factor.

Broadly in line with this finding, a long string of research has found that high levels of government debt (and deficits) tend to lead to an increase in sovereign yields, including by raising the credit risk component captured in sovereign bond spreads.[10] At its turn, this is one channel through which high debt burdens can ultimately impede (long-term) growth, others being higher future distortionary taxation and crowding-out of private investment, financial intermediation (catalyser for banking crisis), lower scope for counter-cyclical fiscal policy, and increased uncertainty.[11] In this respect, higher debt and deficit ratios should be associated with higher $i - g$, through both the interest rate and the growth component.

Another hypothesis regarding the sustained reduction of interest rates in advanced economies is the so-called "global savings glut", formulated by Bernanke (2005) to initially explain capital inflows into the US. According to this hypothesis, an increase of investable capital (excess of saving over investment) in emerging economies, particularly Asian emerging markets and non-OECD oil exporters, has been primarily directed towards the "risk-free" bonds of industrialised countries.

[10] See Codogno et al. (2003), Attinasi et al (2010) and Corsetti et al. (2013) for the effect on spreads and Laubach (2009), Baum et al. (2012) for the effect on long-term sovereign interest rates.

[11] See Burriel et al. (2020) for a review and simulation results with three large scale DSGE models.

Overall, as previously pointed out in Blanchard et al. (1991), a seminal paper on the topic of debt sustainability and its determinants, whether the configuration of negative interest rate-growth differential "could be easily rejected based on theoretical or empirical grounds remains a theoretical curiosum […] Still, there is general agreement that the condition of an excess in the interest rate over the growth rate probably holds, if not always, at least in the medium and long run" (*p*.15). In his most recent work (Blanchard, 2019), the author challenges this conclusion, at least for the perceived "risk-free" government debt.

Turning to the empirical literature, most papers have recently focused on the declining trend of the real interest rates (or the natural rate of interest), while studies on the $i-g$ differential for the government debt are more scarce. Escolano (2010) presents the methodological issues associated with debt dynamics, including the interest-rate differential, and makes the point that a rule of thumb is to consider the long-run $i-g$ in developed economies at around 1 *pp*, as shown also by averages over 1980s-2007 for most mature economies. For examples of long-run sustainability gap calculations in selected OECD countries, Blanchard et al. (1991) assumes a constant value for $i-g$ at 2 *pp* (considered "a reasonable if perhaps conservative assumption" *(p. 17),* with sensitivity analyses conducted for positive values between 0.5 and 4.0 and for a negative value at -1.0). More recently, Mauro and Zhou (2020) documents that, contrary to the usual assumption, negative differentials have occurred more often than not in both advanced and emerging economies over a long period spanning up to 200 years. Yet, for the most recent period (post-1980s), data for developed countries broadly concur with those presented in Escolano (2010).

Escolano et al. (2017) investigates the puzzle of (large) negative interest rate-growth differential in emerging and developing countries. They conclude that this is largely due to real interest rates well below market equilibrium–stemming from financial repression and captive and distorted markets, whereas the income catch-up process plays a relatively modest role. By analysing a large sample of both advanced and emerging economies, the authors also find that high public debt and large fiscal deficits tend to be consistently and positively associated with $i-g$.

Turner and Spinelli (2011) investigate the reasons behind the recent decline in $i-g$ for a panel of 23 OECD economies. Their results suggest that the fall is partly explained by lower inflation volatility associated with more credible monetary policy regimes, trend that is expected to continue. However, the study also finds determining factors that are likely to be reversed in the future, including the very low monetary policy rates, the "global savings glut" and the effect which the European Monetary Union had in reducing long-term interest differentials in the pre-crisis period. Finally, the study also finds that $i-g$ is likely to rise in the future because the number of countries which have debt-to-GDP ratios above a threshold at which there appears to be an effect on sovereign risk premia (i.e., 75% of GDP) has risen sharply.

Finally, a more recent study, Barrett (2018) seeks to simulate interest rate-growth differentials and public debt limits in advanced economies based on an extended model of Ghosh et al. (2013). While starting from the premise that $i - g$ have actually been negative for very long periods (since 1880s) for several (perceived) safe-haven countries, and producing negative point estimates, the study cannot reject positive values at standard significance levels.

III. Empirical analysis

In this paper, we first seek to identify the main driving factors for the interest rate-growth differentials on government debt for euro area countries using panel econometric techniques. In line with the literature review, we investigate the fiscal and macroeconomic fundamentals, as well as the financial, demographic and institutional factors that may be relevant across a core group of euro area countries. Various robustness checks are performed including: (i) across country groups: apart from the first 12 members of the euro area (EA-12) as the core group of matured, high income economies in the euro area, we also look at larger samples, including other OECD advanced economies (Denmark, Sweden, United Kingdom, United States and Japan) and the other euro area countries; (ii) across various periods: apart from 1985-2017 as a base period for which good data coverage is available for the EA core economies, we focus also on the euro area period (1999-2017)[12]; (iii) across panel econometric techniques.

Second, we employ a VAR framework to forecast $i - g$ paths for the core EA countries over the medium run (5-year simulation period) and assess risks surrounding such forecasts. This analysis focuses on a Bayesian panel VAR, based on a simple specification identified in the empirical analysis on determinants. We also provide country-specific forecasts, based on a deterministic DSA framework, following Bouabdallah et al. (2017).

1. Panel data analysis

We first investigate empirically the determinants of $i - g$ in a panel data setting. We do not find it particularly useful to conduct the empirical analysis on this topic solely based on individual country series, especially those dating backwards for very long periods of time (as done in other studies). Such an approach would have little to do with today's modern economies. In addition, it would be difficult to control for many potentially relevant factors for which only relatively short time series are available. By taking into account both country and time information, we consider the panel analysis well suited to identify the significant determinants of our dependent variable.

The starting point for our analysis is an unbalanced annual panel for the period 1985-2017, for which consistent time series for most explanatory variables are available (at least) for the core EA countries.

[12] Appendix 1 shows some results for the period 1971-2017 for which consistent data coverage is much more limited.

As discussed in the literature review, the components of the differential (interest rate and growth rate, separately) have been the subject of many studies, which identify a wide range of determinants. In this study, we are particularly interested in explaining the *differential*, i.e. what determines the surplus (or shortfall) of $i\ over\ g$. Based on the existing literature, we aim at testing empirically a series of hypotheses, with a special focus on euro area countries, including:

First, countries with weaker fiscal and macroeconomic fundamentals are likely to experience higher $i - g$, as (real) growth prospects are weaker and interest rate (premia) higher.

Second, ageing tends to reduce $i - g$, as it may induce a larger decline in interest rates than in growth. The currently observed demographic trends are commonly highlighted as one of the possible causes of the low growth-low interest rate environment of the last couple of decades. However, it is not clear *a priori* whether the two effects balance each other or which effect is stronger.

Third, a looser monetary policy tends to lower $i - g$, at least over the short- to medium-run, as the interest rate on government debt declines and nominal growth is stimulated.

Fourth, which other factors are relevant determinants of $i - g$ in the euro area? Does the global saving glut hypothesis hold also for the $i - g$ differential and for the euro area in particular? How do $i - g$ trends look over various periods of time and across country groups?

1.a Base specification

Our base specification employs the Driscoll-Kraay fixed effects panel estimator, with standard errors robust to cross-sectional and temporal dependence, over the period 1985-2017, for the 12 first members of the euro area, as follows:

$$(i - g)_{it} = \beta X_{it} + \nu_i + \varepsilon_{it}$$

where $(i - g)_{it}$ denotes the interest-growth rate differential on general government debt for country i at time t (annual data and 5-year averages), X_{it} the vector of explanatory variables, ν_i the country-specific fixed effects and ε_{it} the error term. With the Driscoll-Kraay estimator, the error structure is assumed to be heteroskedastic, autocorrelated (here) up to lag 3 and correlated between groups. The Driskoll-Kraay estimator is chosen given that it is particularly suited for panels with larger time dimension (T) and smaller cross-sectional dimension (N), as well as for its robustness to potential cross-country correlation. Appendix 3 provides robustness checks with alternative estimators, especially GMM dynamic panel models, which may be more appropriate at tackling endogeneity issues, but are not especially suited for panels with larger T. Results remain overall robust.

In line with the literature and in view of testing the above-hypotheses, X_{it} includes in the basic specification the following variables:

(i) government debt and primary balance (budget balance excluding interest payments) [13] ratios-to-GDP, as main fiscal variables. In an alternative specification, the two variables are replaced by the change in the debt ratio. These variables have been found in previous empirical work to impact both sovereign yields/spreads and growth;

(ii) output gap, current account balance (private component) and TFP growth, as key short- and longer-term macroeconomic fundamentals. In the assessment of macroeconomic factors, total factor productivity growth is a key long-term determinant of sustained economic growth, while the output gap is employed as a measure of an economy's position in the cycle. The private current account balance is as an important determinant of both macroeconomic imbalances and demand for capital inflows;

(iii) age dependency ratio and population growth, as main ageing-related determinants, and

(iv) the short-term interest rate (3-month government T-bill rate), as one proxy for the stance of monetary policy. Various other variables are investigated in further robustness tests.

The main source of data is Ameco (latest available vintage at the time of writing, as per European Commission Autumn 2018 forecast). Where not available, data series are extrapolated with growth rates of earlier Ameco vintages or other sources (IMF, OECD, World Bank, etc). For more details on data sources and availability, see Appendix 5.

The results of the basic model are presented in Table 1. Several variations are included, i.e. with annual data (contemporaneous in Models 1 and 4, or 1-year lagged explanatory variables in Models 2 and 3) or 5-year non-overlapping averages to capture longer-time effects (Models 5 and 6). Moreover, we also include a common time effect and proxy for external developments in $i - g$ (the differential for the United States) in Model 4 with annual data and time (period) fixed-effects in Model 6 with 5-year averages.[14] Model 4 (M4), with highest goodness of fit with annual data, will be used as the basic model choice for most robustness checks.

As hypothesised, most variables turn out to be statistically significant and have the expected sign across the various specifications. Contemporaneous variables seem to explain a larger proportion of the variation in $i - g$ compared to the lagged variables as indicated by the R2-within goodness of fit measure. On the other hand, the model with lagged variables reduces the potential for endogeneity and most variables remain statistically significant when used in lagged form. The effects remain persistent for 5-year averages for all variables apart from the output gap and the short-term interest rate, while the primary balance ratio turns also significant only at a 10% confidence level. The results are intuitive given that these regressions average over (regular) economic cycle lengths and both the

[13] Calculated as the difference between the total current account balance and the government primary fiscal balance (to mitigate endogeneity issues, government interest payments are deducted from the fiscal balance).

[14] To avoid overloading the annual model with time fixed-effects for the longer period starting in 1985, we include time fixed effects only in the model with 5-year averages and, for the annual model, in the variant for the period 1999-2017. Furthermore, the model with 5-year averages and N>T uses the (similar) Newey estimator instead of Driscoll-Kraay.

primary deficit and the short-term interest rate are likely to have stronger short-term (annual) impulse.

In terms of groups of explanatory variables, based on these regressions, higher debt and lower primary balances (higher primary deficits) in EA-12 tend to be associated, on average, with higher $i - g$, keeping all the other factors constant For every 10 percentage point (*pp*) increase in the debt ratio and every 1 *pp* increase in the deficit, $i - g$ tends to increase by 0.4-0.6, and respectively, 0.2-0.4 *pp*, on average. The *change in debt* (1-year lagged) is also found to be statistically significant, positive and robustly associated with $i - g$. Somewhat surprisingly, no robust non-linearities in the debt level (thresholds) are identified for the EA-12 sample in explaining $i - g$. This contrasts with results in Turner and Spinelli (2011) for the OECD sample and with (own) previous findings on debt-related thresholds for growth. An explanation could be that potential thresholds (as found in the empirical literature) are dissimilar for yields/spreads and for growth. Furthermore, the current compression of spreads at high debt levels may explain the break-up in this relationship more recently.

Table 1: Main explanatory factors for interest rate-growth differential in EA-12 over 1985-2017

MODEL/ VARIABLES	**Model 1** Annual data contempora-neous Xi, country FE	**Model 2** Annual data 1-year lagged Xi, country FE	**Model 3** Annual data 1-year lagged Xi, country FE	**Model 4 (M4)** Annual data contemporaneous Xi, country FE and common time effect	**Model 5** 5-year non-overlapping averages, country FE	**Model 6** 5-year non-overlapping averages, country and year FE
Government debt ratio	0.0382**	0.0585***		0.0426**	0.0485***	0.0439**
	(0.0154)	(0.0144)		(0.0147)	(0.0176)	(0.0181)
Primary balance ratio	-0.278***	-0.404***		-0.248***	-0.190*	-0.202*
	(0.0628)	(0.0774)		(0.0525)	(0.103)	(0.104)
Output gap	-0.386***	0.105	0.0302	-0.390***	-0.0918	
	(0.0785)	(0.125)	(0.137)	(0.0880)	(0.123)	
Current account balance (private)	-0.223***	-0.349***	-0.270***	-0.204***	-0.233***	-0.244***
	(0.0560)	(0.0824)	(0.0742)	(0.0507)	(0.0835)	(0.0823)
TFP growth	-0.945***	-0.560***	-0.360**	-0.826***	-0.997***	-1.109***
	(0.0644)	(0.146)	(0.132)	(0.0820)	(0.207)	(0.224)
Dependency ratio	-0.358***	-0.280***	-0.163**	-0.341***	-0.474***	-0.408***
	(0.0447)	(0.0555)	(0.0550)	(0.0436)	(0.0908)	(0.0948)
Population growth	-2.424***	-1.715**	-2.206***	-2.088***	-3.472***	-3.626***
	(0.227)	(0.734)	(0.695)	(0.264)	(0.811)	(0.878)
Short-term interest rate	0.189**	0.235***	0.0708	0.0984	0.0731	
	(0.0633)	(0.0592)	(0.0785)	(0.0801)	(0.0662)	
Change in government debt			0.283***			
			(0.0700)			
(i-g) US				0.304***		
				(0.0757)		
Observations	371	367	371	371	76	76
Number of countries	12	12	12	12	12	12
R2 within	0.659	0.326	0.318	0.677	0.690	0.761

Notes: Standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1. Models 1-4 use the Driscoll-Kraay fixed effects (FE) estimator, Models 5-6 (with restricted time periods and N>T) use the Newey FE estimator.

The differential also tends to increase in bad times (by about 0.4 pp for each 1 pp worsening of the output gap). Countries with higher (private) current account deficits tend to have a higher differential, with the size of the effect similar with that of the public sector deficit. Technological progress or other factors that increase TFP growth lead to a decline in $i - g$. Controlling for other (unspecified) common external factors, subsumed in the time variation of the US differential, indicate a trend in the same direction: an increase (or a decline) in the US $i - g$ by 1 pp is associated with an increase (decline) of the $i - g$ in the EA-12 by 0.3 pp, other factors kept constant.

The impact of ageing is more difficult to disentangle. A higher dependency ratio is associated with lower $i - g$, while lower population growth tends to increase the differential. This result could be justified in so far that ageing induces first higher saving (larger supply of loanable funds and hence a decline in interest rate), without affecting to the same extent, or affecting only later, the growth rate of the economy, while lower population growth could have a more pronounced and quicker effect on growth (through lower consumption and lower saving) than on the interest rate.[15]

A monetary policy tightening, proxied (here) by an increase in the short-term interest rates (3-month T-bill country-specific interest rates), is in most cases found to induce an increase in the $i - g$ on government debt. Yet, for the period 1985-2017, when a time trend (or time dummies) is introduced in the regressions, the short-term interest rate loses significance. As it will be shown in the next set of regressions, the monetary policy variables prove to be more robust for the euro period (1999-2017).

1.b Period effects, the impact of euro adoption and the great financial and sovereign debt crisis (GFC)

In this section, we analyse if and how the determinants of $i - g$ changed over the euro area period (1999-2007), which was the impact of the euro adoption and which were the effects of the GFC. Table 2 below shows the simple averages of $i - g$ across EA12 countries over various periods. The average over the euro area period is lower than the average over the entire time sample (1985-2017). After a period of negative values on average before the onset of the GFC in 2008, especially on account of the economies experiencing overheating (albeit the value corresponding to the euro area aggregate remains positive at 0.6 over 1999-2017), the differential increased dramatically during the crisis and declined thereafter. During the recent period, especially since 2015 (and before the COVID-19 crisis hit), the differential has been much lower.

[15] The results with population growth are confirmed also in separate regressions by components of $i - g$, where the variable is statistically significant only in growth regressions and not in the interest rate regression. The effect of the dependency ratio is not clear in separate regressions.

Table 2: Interest rate-growth differential in EA-12 over various periods

i-g	Overall period		Period before GFC		Period of GFC	Period after GFC	Recent period	
	1985-2017	1999-2017	1985-2007	1999-2007	2008-11	2012-17	2015-2017	2017
EA12 simple average	0.9	0.6	0.5	-0.7	3.2	0.6	-0.8	-1.7

Source: own calculations based mainly on the European Commissions' Ameco dataset (Autumn 2018 vintage). Notes: for the period 1999-2007, the differential for the euro area aggregate debt was positive at 0.6 pp, reflecting the lower weight in the euro area of small countries with deeply negative average i-g such as Luxembourg or Ireland. In the recent period, the differential turned negative for both the simple average of our EA12 sample, as well as for the euro area aggregate, as of 2015.

Next, we check the determinants of $i - g$ for the euro area period by running the regression models in Table 1 for the restricted period 1999-2017. Compared with Table 1, we make slight adjustments related to the inclusion of yearly dummies in Model 5 and dropping the 5-year average regressions for which too few time observations would be available. The results are presented in Table 3.

Table 3: Main explanatory factors for interest rate-growth differential in EA-12 over 1999-2017

MODEL/ VARIABLES	**Model 1** Annual data contemporaneous Xi, country FE	**Model 2** Annual data 1-year lagged Xi, country FE	**Model 3** Annual data 1-year lagged Xi, country FE	**Model 4 (M4)** Annual data contemporaneous Xi, country FE and common time effect	**Model 5** Annual data contemporaneous Xi, country and year FE
Government debt ratio	0.0256*	0.0919***		0.0313***	0.0370***
	(0.0133)	(0.0293)		(0.00902)	(0.0111)
Primary balance ratio	-0.226***	-0.518***		-0.221***	-0.258***
	(0.0503)	(0.0883)		(0.0452)	(0.0558)
Output gap	-0.314***	0.117	-0.0646	-0.347***	-0.337***
	(0.0560)	(0.150)	(0.120)	(0.0540)	(0.0630)
Current account balance (private)	0.0610*	-0.0863	0.0155	0.0438	0.0320
	(0.0335)	(0.0801)	(0.0406)	(0.0340)	(0.0355)
TFP growth	-0.955***	-0.374**	-0.194	-0.815***	-0.755***
	(0.0388)	(0.165)	(0.172)	(0.0662)	(0.0839)
Dependency ratio	-0.489***	-0.132	0.0305	-0.466***	-0.457***
	(0.0483)	(0.132)	(0.190)	(0.0503)	(0.0612)
Population growth	-1.343***	1.456	0.503	-1.122**	-0.925*
	(0.393)	(1.142)	(0.892)	(0.388)	(0.450)
Short-term interest rate	0.320***	1.118***	0.727**	0.283***	0.397***
	(0.0661)	(0.347)	(0.289)	(0.0764)	(0.0990)
Change in government debt			0.311***		
			(0.0884)		
(i-g) US				0.221***	
				(0.0548)	
Observations	226	226	226	226	226
Number of countries	12	12	12	12	12
R2 within	0.814	0.417	0.403	0.825	0.835

Notes: Standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1. All models use the Driscoll-Kraay fixed effects (FE) estimator.

The previous results are broadly confirmed, with two main exceptions: the current account variable and the short-term interest rate change significance. The former is no longer statistically significant in determining the differential for the euro area period (it remains significant in further regressions for the period 1985-2017 that include the euro area dummy). As hinted in the previous section, the short-term interest rate turns statistically significant for the euro area period even when yearly dummies are included (Model 5) or other time trend-related variables are controlled for (Model 4).

Next we try to better disentangle trends in the differential over the euro area or the post-crisis period through the inclusion of time dummies, with results reported in Table 4.

Table 4: Period effects, the impact of euro adoption and the great financial and sovereign debt crisis (1985-2017)

MODEL/ VARIABLES	**Model 1** OLS and time trend	**Model 2** OLS and euro area period dummy	**Model 3** OLS and post-crisis period dummy	**Model 4** Base model (M4) and euro area period dummy	**Model 5** Base model (M4) and post-crisis period dummy
Government debt ratio				0.0407**	0.0532***
				(0.0143)	(0.0144)
Primary balance ratio				-0.247***	-0.284***
				(0.0539)	(0.0514)
Output gap				-0.360***	-0.394***
				(0.0884)	(0.0790)
Current account balance (priv.)				-0.193***	-0.182***
				(0.0473)	(0.0485)
TFP growth				-0.884***	-0.888***
				(0.101)	(0.0879)
Dependency ratio				-0.322***	-0.296***
				(0.0423)	(0.0451)
Population growth				-2.044***	-1.679***
				(0.262)	(0.259)
Short-term interest rate				0.0364	0.0508
				(0.0815)	(0.0832)
(i-g) US				0.268***	0.312***
				(0.0835)	(0.0783)
Time trend	-0.00922				
	(0.0205)				
Euro area period dummy		-0.747*		-0.819*	
		(0.396)		(0.463)	
Crisis dummy (post-2007)			1.164***		-1.326***
			(0.410)		(0.305)
Observations	389	389	389	371	371
Number of countries	12 (pooled)	12 (pooled)	12 (pooled)	12	12
R2 within	0.001	0.009	0.020	0.681	0.688

Notes: Standard errors in parentheses. Significance under confidence intervals: *** p<0.01, ** p<0.05, * p<0.1. The time trend is the year variable; the Euro area period dummy equals 1 from 1999 (the year of the euro adoption) onwards and zero afterwards; the Crisis dummy (post-2007) denotes the period from the onset of the great financial and sovereign debt crisis

(GFC) and equals 1 from 2008 onwards and zero otherwise. Models 1-3 use the pooled OLS estimator, while models 4-5 use the Driscoll-Kraay fixed effects (FE) estimator.

First, we show that while no discernible (continuous) downward trend exists in the EA-12 $i-g$, on average, over the period 1985-2017 (Model 1), the differential seems to be (weakly statistically significantly) lower over the euro area period than before (Model 2) and significantly higher after the onset of the crisis (post-2007, Model 3). When all the other relevant variables are controlled for (as in our basic model M4), the coefficient for the euro area period dummy remains broadly unchanged (see Model 4 column), but the one for the post-crisis period changes significantly (Model 5). That is, controlling for the change in fiscal and macroeconomic conditions (as well as other factors and country fixed effects), the post-crisis differential has actually been statistically significantly *lower* by about 1.3 pp over the period 2008-2017 than during the period 1985-2007 (while the absolute mean indicated in Model 2 is by 1.2 pp higher).

1.c Comparison with other economies

Most of the findings for the mature euro area economies (EA-12) remain robust for the larger group of advanced economies covered (AE-17, adding Denmark, Sweden, United Kingdom, United States and Japan) and, to some extent, for an extended sample, including the euro area economies in the income catching-up process (AE-24). The results are presented for both periods 1985-2017 and the euro area period, the latter with country and time fixed effects (see Table 5).

In terms of fiscal variables of our base specification, higher debt levels are generally associated with higher $i-g$ also in extended samples. This effect seems to be stronger for the core euro area countries. When the other non-euro area mature advanced economies are included (AE-17), the debt level remains positive and statistically significant, but only at 10% level (albeit with a p-value of 0.056). The primary deficit remains positively associated with $i-g$ also for the AE-17 sample, while it loses significance for the broader sample including the newer EA members. As for the other variables, the output gap, TFP growth and dependency ratio remain robust across the three samples. The coefficient of the output gap is larger for the broader sample, which includes the more volatile, catching-up economies. Population growth, however, loses significance in most specifications for the AE-24 sample. As regards the current account variable, the results remain similar for the larger sample of mature advanced economies: larger surpluses are associated with lower $i-g$ for the longer period since 1985, while the significance disappears for the more recent period. When the newer EA members are included, the variable changes signs and becomes strongly statistically significant, i.e. for the period since 1999, higher current account deficits are associated, on average, with lower $i-g$.

Table 5: Comparison with other economies

MODEL/ VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	EA-12	AE-17	AE-24	EA-12	AE-17	AE-24
	Annual data contemporaneous Xi, country FE			Annual data contemporaneous Xi, country and time FE		
	1985-2017			1999-2017		
Government debt ratio	0.0382**	0.0225*	0.0203**	0.0370***	0.0162*	0.0217**
	(0.0154)	(0.0109)	(0.00977)	(0.0111)	(0.00767)	(0.00800)
Primary balance ratio	-0.278***	-0.234***	0.0183	-0.258***	-0.239***	0.0116
	(0.0628)	(0.0628)	(0.0534)	(0.0558)	(0.0749)	(0.0713)
Output gap	-0.386***	-0.456***	-0.576***	-0.337***	-0.383***	-0.610***
	(0.0785)	(0.0748)	(0.109)	(0.0630)	(0.0555)	(0.115)
Current account balance (private)	-0.223***	-0.193***	0.0885	0.0320	-0.0019	0.264***
	(0.0560)	(0.0395)	(0.0865)	(0.0355)	(0.0320)	(0.0760)
TFP growth	-0.945***	-0.911***	-0.988***	-0.755***	-0.766***	-0.920***
	(0.0644)	(0.0528)	(0.103)	(0.0839)	(0.0845)	(0.0878)
Dependency ratio	-0.358***	-0.326***	-0.265***	-0.457***	-0.355***	-0.230***
	(0.0447)	(0.0392)	(0.0506)	(0.0612)	(0.0492)	(0.0519)
Population growth	-2.424***	-2.431***	-0.667**	-0.925*	-1.427***	0.0907
	(0.227)	(0.287)	(0.246)	(0.450)	(0.397)	(0.288)
Short-term interest rate	0.189**	0.184**	0.201***	0.397***	0.395**	0.0172
	(0.0633)	(0.0657)	(0.0504)	(0.0990)	(0.144)	(0.215)
Observations	371	525	675	226	318	451
Number of countries	12	17	24	12	17	24
R2 within	0.659	0.647	0.596	0.835	0.816	0.769

Notes: Standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1. All models use the Driscoll-Kraay fixed effects (FE) estimator. The model presented is Model 1 from Table 1 as preferred model M4 includes i-g for the US as an explanatory variable for the group of EA-12. The country groups are: EA-12, the core group of matured, high income economies in the euro area and first members. EA-17 includes in addition Denmark, Sweden, UK, Japan and US. EA-24 includes in addition the remaining 7 euro area countries.

1.d Other relevant variable

a. Global saving glut hypothesis

Another hypothesis regarding the sustained reduction of interest rates in advanced economies is the so-called "global savings glut", whereby an increase of investable capital in emerging economies has been primarily directed towards the "risk-free" bonds of industrialised countries. To test the effect of this saving behaviour on $i - g$ for the EA-12, in line with Turner and Spinelli (2011) we use as a proxy the current account balance (surplus) of a group of Asian and commodity exporting economies[16] as a share of world's total GDP.

Table 6: Testing for the global saving glut hypothesis (EA-12)

MODEL/ VARIABLES	**Model 1** 1985-2017	**Model 2** 1999-2017	**Model 3** 1985-2017	**Model 4** 1999-2017
Government debt ratio	0.0396**	0.0313***	0.0345**	0.0264*
	(0.0138)	(0.00909)	(0.0140)	(0.0131)
Primary balance ratio	-0.264***	-0.231***	-0.296***	-0.248***
	(0.0540)	(0.0491)	(0.0617)	(0.0545)
Output gap	-0.376***	-0.341***	-0.365***	-0.308***
	(0.0839)	(0.0537)	(0.0743)	(0.0531)
Current account balance (priv.)	-0.209***	0.0425	-0.226***	0.0555
	(0.0520)	(0.0346)	(0.0547)	(0.0348)
TFP growth	-0.869***	-0.826***	-0.985***	-0.957***
	(0.0942)	(0.0647)	(0.0654)	(0.0348)
Dependency ratio	-0.331***	-0.464***	-0.339***	-0.481***
	(0.0436)	(0.0471)	(0.0486)	(0.0437)
Population growth	-2.116***	-1.100**	-2.388***	-1.262**
	(0.256)	(0.414)	(0.200)	(0.426)
Short-term interest	0.0724	0.302***	0.126*	0.353***
	(0.0788)	(0.0796)	(0.0646)	(0.0717)
(i-g) US	0.258**	0.205***		
	(0.0926)	(0.0572)		
Global saving glut proxy	-0.750	-0.294	-1.183**	-0.632**
	(0.493)	(0.302)	(0.468)	(0.265)
Observations	371	226	371	226
Number of countries	12	12	12	12
R2 within	0.680	0.825	0.669	0.817

Notes: Standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1. All models use the Driscoll-Kraay fixed effects (FE) estimator.

The global savings glut variable (gsg) seems be associated with a decline in i-g in the sample of matured euro area economies only when time effects are not controlled for (see Table 6). As a variable that is common across countries, with a statistically significant upward trend for the period 1985-2017 (though not for 1999-2017), its statistical significance drops when the US i-g (or a time trend) is included (see Models 1-2 vs. Models 3-4). This could be interpreted as spurious correlation due to a common time trend. However, given the theoretical foundation and evidence of increased holdings of

[16] The group of countries include: Angola, Bahrain, Brunei, China, Hong Kong, Japan, Korea, Kuwait, Malaysia, Nigeria, Qatar, Saudi Arabia, Singapore, Thailand and United Arab Emirates.

advanced economies' bonds by emerging economies, it is difficult to fully reject the hypothesis. Moreover, if any, the trend in the US i-g is likely to be impacted most by the global saving glut. With no time effects, gsg appears to be significantly associated with a decline in interest rates (without a similar decline in growth) even when controlling for the counter-party current account position. The effect seems to turn weaker over time: when statistically significant, the size of the coefficient is almost double over the longer period (1985-2017) compared to more recently (1999-2017) (see Model 3 vs. Model 4). As shown in separate regressions, the effect is also stronger in the larger sample of advanced economies than in EA-12. Overall, given the loss of significance in some specifications, these results should be considered with caution.

b. More on monetary policy-related variables

In this section, we conduct robustness checks on the impact of monetary policy-related variables. Table 7 shows models that include alternatives to the short-term interest rate (proxied by the country-specific 3-month T-bill rate; see Model 1 in column 1). Model 2 includes Euribor, Model 3 the deposit facility rate, Model 4 the marginal lending facility rate; Model 5 the slope of the yield curve (proxied by the difference between the long-term, benchmark 10-year government bond yield and the short-term interest rate), while Model 6 includes the (country-specific) long-term interest rate.[17]

As with the short-term interest rate, Euribor and the two other monetary policy rates[18] in Models 3-4 turn out statistically significant and positively associated with $i - g$, with coefficients similar in size: a 1 pp decrease in the short-term monetary policy rates induces a reduction in the differential of about 0.3-0.4 pp on average. As expected, the 10-year government bond yield is also found positively associated with $i - g$, as it enters directly in the calculation of the implicit interest rate (average cost of government debt). In this case, a 1 pp decrease in the (marginal) long-term interest rate induces a reduction of the differential of about 0.2 pp on average (inter alia, reflecting the gradual feeding of the marginal interest rate into the average cost in line with the average maturity of government debt in the euro area). On the other hand, and differently from Turner and Spinelli (2011) for the OECD sample, the slope of the yield curve is not found to be a significant determinant for $i - g$ in the euro area for the period 1999-2017. The other determinants remain broadly robust.

[17] We also test for the impact of a "shadow short rate" capturing the stance of monetary policy, particularly in zero lower bound environments, defined as per Krippner (2013). The variable has the expected sign, but it is found to be statistically significant only for the whole sample of advanced economies and not for our core EA-12 sample.

[18] We also controlled for the main refinancing operations at fixed rate, but its coefficient is not statistically significant. It is worth noting that the main refinancing operations underwent a period of variable rate between 2000 and 2008 which reduces the number of available observations.

Table 7: Effects of various monetary policy-related variables (EA-12, 1999-2017)

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Government debt ratio	0.0313***	0.0360***	0.0304***	0.0357***	0.0165	0.0220**	0.0267**	0.0182***	0.0142**
	(0.00902)	(0.0103)	(0.00916)	(0.0103)	(0.00996)	(0.00999)	(0.0113)	(0.00407)	(0.00538)
Primary balance ratio	-0.221***	-0.226***	-0.228***	-0.231***	-0.175***	-0.205***	-0.190***	-0.149**	-0.112**
	(0.0452)	(0.0442)	(0.0469)	(0.0461)	(0.0459)	(0.0438)	(0.0417)	(0.0663)	(0.0398)
Output gap	-0.347***	-0.410***	-0.401***	-0.400***	-0.325***	-0.305***	-0.350***	-0.253***	-0.166***
	(0.0540)	(0.0601)	(0.0574)	(0.0544)	(0.0562)	(0.0530)	(0.0519)	(0.0688)	(0.0474)
Current account balance (private)	0.0438	0.0321	0.0196	0.0167	0.0198	0.0322	0.0252	0.0721*	0.0329
	(0.0340)	(0.0278)	(0.0287)	(0.0291)	(0.0329)	(0.0355)	(0.0333)	(0.0346)	(0.0438)
TFP growth	-0.815***	-0.823***	-0.840***	-0.829***	-0.830***	-0.810***	-0.849***	-0.986***	-1.202***
	(0.0662)	(0.0717)	(0.0720)	(0.0697)	(0.0666)	(0.0636)	(0.0773)	(0.133)	(0.198)
Dependency ratio	-0.466***	-0.440***	-0.459***	-0.425***	-0.525***	-0.452***	-0.510***	-0.103***	-0.0499
	(0.0503)	(0.0549)	(0.0508)	(0.0576)	(0.0702)	(0.0636)	(0.0482)	(0.0310)	(0.0710)
Population growth	-1.122**	-1.003**	-1.232**	-1.075**	-1.617***	-1.198***	-1.445***	-1.506***	-0.543
	(0.388)	(0.378)	(0.410)	(0.394)	(0.383)	(0.364)	(0.380)	(0.386)	(0.393)
(i-g) US	0.221***	0.191***	0.195***	0.202***	0.246***	0.228***	0.234***	0.225**	0.215***
	(0.0548)	(0.0592)	(0.0531)	(0.0550)	(0.0463)	(0.0513)	(0.0581)	(0.0986)	(0.0303)
Short-term interest rate	0.283***								
	(0.0764)								
Euribor		0.393***							
		(0.125)							
Deposit facility rate			0.384**						
			(0.140)						
Marginal lending facility rate				0.339**					
				(0.122)					
Slope yield curve					-0.134				
					(0.0949)				
Long-term interest rate (10-year government bond yield)						0.207***			
						(0.0283)			
Monetary policy assets (log)							-0.251	-0.747***	
							(0.200)	(0.132)	
PSPP assets (log)									-0.189*
									(0.0898)
Observations	226	226	226	226	226	226	226	226	31
Number of countries	12	12	12	12	12	12	12	12	11
R2(within)	0.825	0.827	0.829	0.830	0.818	0.825	0.816	0.778	0.685
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	NO	NO

Notes: Standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1. All models use the Driscoll-Kraay fixed effects (FE) estimator applied to data for the EA-12 sample over the period 1999-2017, apart from Models 8-9, which used the pooled OLS Driscoll-Kraay estimator. The variables "Monetary policy assets" (common across countries in the sample) and "PSPP assets" (country-specific) are used in natural log. For sources of data, see Appendix 5.

Apart from the conventional monetary policy tools, the non-conventional measures, subsumed into the Eurosystem's balance sheet indicators, may have also contributed to the recent significant reduction in the differential for the euro area countries. This would be in line with the existing empirical literature and policy papers, which find that the Assets Purchase Programmes (APP) and, particularly, the public sector purchase programme (PSPP), have contributed to lowering both euro area sovereign yields and helping real growth and inflation recover.[19] We try to evaluate this hypothesis empirically in our sample using balance sheet data on Eurosystem's total monetary policy assets (variable common across euro area countries in the sample) and PSPP assets (asset purchase of individual country bonds for the euro area countries included in the programme). Given the restricted time period for which data is available for the PSPP (only as of 2015) or change significantly for the monetary policy assets (after the crisis and especially as of 2012), we find a statistically significant impact, of the expected sign – higher asset purchases associated with a lower differential – only for the pooled sample estimator and not with fixed-effects (FE). See the last three columns in Table 7, in which we present results with monetary policy assets with FE (Model 7) and without FE (Model 8), while for the PSPP variable (sample of only 33 observations and 11 countries, as Greece was excluded from the PSPP) only without FE. Given, inter alia, the much larger number of observations, the effect is stronger statistically for the monetary policy assets. According to the regression Model 8, a 10% increase in the Eurosystem's monetary policy assets is associated, on average over 1999-2017, with a decline in $i - g$ of 8 *basis points.*

c. Other variables

We have also investigated the potential effects of other variables on $i - g$. The quality of institutions should also be an important determinant of $i - g$ as better institutions support growth and lower sovereign risk premia. Also in our sample for the period 1999-2017, various World Bank indicators for the quality of institutions are generally found to be significantly associated with the differential: better institutions are linked to lower $i - g$. Yet, given the relatively short time span for which the indicators are available (since 2002 without gaps), the strong empirical links with other variables (TFP growth, debt) and the little time variation displayed, the variables are not always robust in our basic specifications when time effects are included. In several specifications, the most robust variables turn out to be the *Regulatory Quality* (a variable measuring the quality of regulations in the context of ease of doing business) and *Voice and Accountability* (a variable partly accounting for the inclusiveness in the process of political decisions and corruption).

[19] See, inter alia, Altavilla et al. (2016) for the positive financial and macroeconomic effects of the OMT announcements, Gambetti and Musso (2017) for positive macroeconomic (real GDP and HICP inflation) effects of the APP during the first two years after the announcement. Vayanos and Vila (2009) model the 'stock effect' of central bank bond purchases, which decreases the 'free-floating' bond supply to be held by investors and hence the compensation they require for it. The literature also shows that the effect of central bank purchases can occur with some lag relative to their announcement.

Other variables investigated relate to the financial and banking sector in an attempt to capture potential signs of financial repression and the depth of financial markets. However, relevant variables such as domestic holdings of government bonds in the banking sector have a relatively limited time span and no robust results were unveiled.[20]

2. Forecast and simulations

The panel regressions in section III.1 analyse a vast set of historical determinants of the interest rate-growth differential. After establishing these relations, we are interested in forecasting the differential over the medium term (up to 5-years, T−T+4) and estimating the probability of the differential returning to positive values. To this end, a panel Bayesian VAR model is considered. The same model is then fitted in two different variants.

The model uses a restricted set of the variables identified in section III.1 to avoid overfitting.[21] Each of the two variants considered consists in a set of three endogenous variables ($i - g$, one fiscal variable and the short term interest rate) and two exogenous variables (TFP growth and dependency ratio variation). The fiscal variable is the government debt ratio in variant 1 and the primary balance in variant 2. As regards the exogenous variables, in the forecast period, TFP growth is assumed to follow the AMECO forecast as available (first two years of the 5-year horizon) and its long term trend (since the start of the EMU) thereafter. The dependency ratio variation is entirely sourced from the European Commission 2018 Ageing Report. As the heterogeneity between countries cannot be ignored, we choose a hierarchical prior distribution, which allows for cross-subsectional heterogeneity: our model thus consists in a set of domestic VARs whose parameters are assumed to have prior distributions with similar mean and variance. The panel VAR is estimated using the EA-10 sample (EA-12 excluding Ireland and Luxembourg[22]) over the (more relevant) EMU period. The model variants are estimated using the BEAR toolbox[23] (see Dieppe et al., 2016) and simulations are computed for 10000 paths. The dependent variable ($i - g$) was tested for panel unit roots with the Levin-Lin-Chu test and was confirmed stationary.

[20] Results with the variables discussed in this sub-section are available upon request.

[21] Furthermore, as the convergence rate of the Gibbs sampling method used in the BVAR decreases for small time series (see Rosenthal 1995) we restrict the number of variables by focusing on fiscal and monetary policy variables.

[22] As mentioned before, Ireland exhibits extremely low $i - g$ for 2015 and 2016 (-15.1 on average) due to a statistical reclassification affecting growth. Luxembourg has also persistent and very low $i - g$, as well as very low government debt with very limited bond issuances, non-typical for advanced economies. The exclusion of these two countries as outliers does not affect the conclusions of Section III.1, where the results remain robust across specifications when regressions are run on the EA-10 sample.

[23] This is achieved by drawing the coefficients of the VAR from a distribution with similar mean and variance following the method proposed by Jarocinski (2010). A limitation of the estimation method as available in the toolbox is that the exogenous variables path in the forecast period must be the same for every country.

We show results across three consecutive forecast vintages based on the European Commission (EC) Ameco datasets. We start with the EC autumn 2018 forecast vintage (and the historical period 1999-2017 used in the previous empirical analysis), continue with the 2019 autumn vintage and finally show results using the EC spring 2020 forecast, which includes the projected impact at the time of the COVID-19 pandemic. The results based on this latest vintage must be interpreted with additional caution, given the high uncertainty surrounding the still on-going crisis, which has drastically affected both economic and financial conditions. We use all of the available historical data for each of the vintages and compute the forecast in the following five years. The estimation period starts in 2000 (allowing for 1 lag) for the three projection vintages used and across all countries (balanced panel).

For illustration, Table 8 below shows selected data and statistics for the full sample used in the BVAR model simulations, the revisions in the most recent historical data between the EC autumn 2018 and spring 2020 vintages and the latest EC forecast of the $i-g$ for 2020-2021.

Table 8: Selected $i-g$ data and statistics used for the BVAR model forecast and the EC forecast under different vintages

Country	BVAR full sample statistics (1999-2019)			EC Autumn 2018 forecast vintage			EC Spring 2020 forecast vintage				
				History	Forecast		History			Forecast	
	1999	Min	Max	2017	2018	2019	2017	2018	2019	2020	2021
Belgium	1.9	-1.4	5.6	-1.0	-1.4	-1.2	-1.4	-0.9	-1	7.8	-6.6
Germany	3.1	-2	7.8	-2.1	-2	-2.4	-2.0	-1.6	-1.4	5.7	-6.6
Greece	1.5	-4.8	13.1	-0.3	-0.7	-1.2	-0.3	-0.6	0.2	11.4	-7
Spain	-1.3	-4.1	7.8	-1.6	-1.4	-1.4	-1.7	-0.9	-1.2	11.5	-6
France	1.5	-1.3	6.4	-0.9	-0.7	-1.1	-0.9	-0.7	-1.3	8.4	-7.2
Italy	2.6	0.1	7.7	0.9	0.4	0.5	0.5	1.1	1.3	11.2	-5.2
Netherlands	0.2	-3.4	7	-2.4	-3.4	-3.4	-2.5	-3.2	-3.4	7.3	-5.1
Austria	1.8	-2	6.4	-1.5	-2.3	-1.8	-1.3	-2	-1.3	6.4	-4.3
Portugal	-1.7	-2.1	8.5	-1.3	-0.7	-0.6	-2.1	-1.5	-1.4	8.3	-4.5
Finland	1.2	-4.2	10.3	-1.9	-2.3	-2.3	-2.2	-1.9	-1.3	5.9	-4.6

Source: EC Ameco database and authors' calculations. BVAR full sample statistics based on EC spring 2020 vintage.

Table 9 presents forecast results based on our BVAR model for the three EC vintages using (unrevised) historical data as available in each vintage (up to 2017 in the first vintage and up to 2019 in the third vintage) and the EC projections for the exogenous variable TFP growth. We first show the median of the $i-g$ distribution in the year 2022 (end of horizon in the first vintage and common point across the three data vintages considered) for the two panel BVAR model variants. Then, we then present the end of the forecast horizon (T+5) median and, finally, the average $i-g$ over the period 2018-2022, common across the three vintages for comparison purposes. The entire projected path of $i - g$ is presented in Chart 3 for Germany and Italy for illustration and for all countries in Appendix 4.

Table 9: Median forecast for $i - g$ with the three vintage

Country	EC Autumn 2018 vintage				EC Autumn 2019 vintage					EC Spring 2020 vintage				
	2022 (T+5)			2018-2022	2022			2023 (T+5)	2018-2022	2022			2024 (T+5)	2018-2022
	Variant 1	Variant 2	Average models	Average models	Variant 1	Variant 2	Average models	Average models	Average models	Variant 1	Variant 2	Average models	Average models	Average models
Belgium	-0.5	-0.7	-0.6	-1.1	-1.5	-1.5	-1.5	-1.5	-1.1	-3.2	-2.6	-2.9	-2.4	-0.6
Germany	-1.2	-0.9	-1.1	-1.8	-1.8	-1.6	-1.7	-1.7	-1.5	-3.7	-3.4	-3.5	-2.8	-1.1
Greece	1.0	0.1	0.5	0.0	0.5	-1.6	-0.5	-0.3	-0.8	-1.3	-3.0	-2.2	-1.4	-0.4
Spain	-0.1	-0.8	-0.5	-1.3	-0.5	-1.3	-0.9	-0.8	-0.9	-2.7	-2.6	-2.6	-1.9	-0.4
France	-0.2	-0.6	-0.4	-1.0	-0.6	-1.2	-0.9	-0.8	-0.8	-2.5	-2.6	-2.5	-1.7	-0.6
Italy	1.1	0.8	0.9	0.4	0.8	0.4	0.6	0.6	0.9	-1.0	-1.1	-1.0	-0.4	1.4
Netherlands	-0.8	-0.9	-0.8	-1.3	-1.6	-1.9	-1.7	-1.7	-2.0	-3.5	-3.8	-3.6	-3.0	-2.2
Austria	-0.7	-1.0	-0.9	-1.7	-1.8	-2.0	-1.9	-1.8	-2.1	-3.8	-4.0	-3.9	-2.9	-1.9
Portugal	0.7	0.1	0.4	-0.5	-0.1	-1.3	-0.7	-0.4	-1.0	-2.3	-3.4	-2.9	-1.8	-1.0
Finland	-0.4	-0.6	-0.5	-1.3	-1.1	-1.2	-1.1	-1.1	-1.3	-3.6	-2.7	-3.1	-2.4	-0.3

Source: Author's calculations based on real time AMECO data and forecasts (EC autumn 2018, autumn 2019 and spring 2020 forecasts). Notes: Variants 1 and 2 are panel Bayesian VARs with the short term interest rates and a fiscal variable (debt ratio in Variant 1 and primary balance ratio in Variant 2) as endogenous variables and TFP growth and dependency ratio variation as exogenous variables.

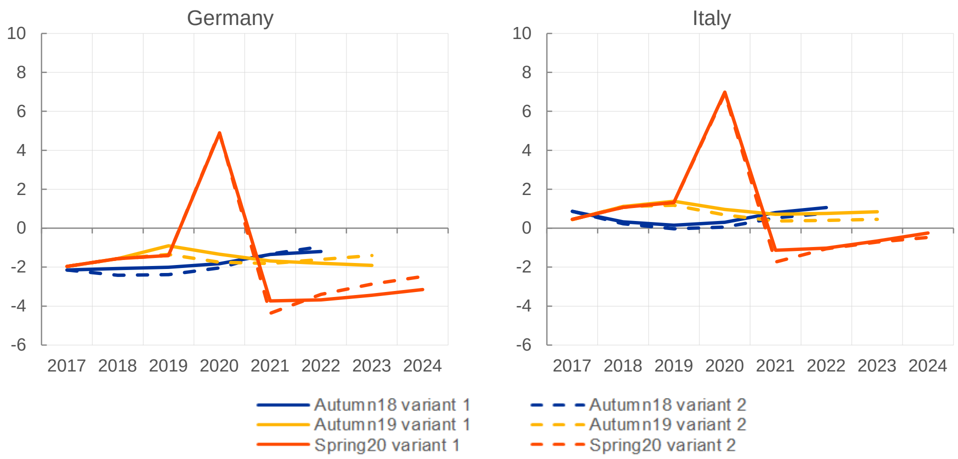
Overall, the following conclusions can be drawn from this exercise. First, the differential is generally projected to remain negative[24] over the medium-term in the euro area countries studied across the various forecast vintages. Exceptions are Italy, under most model results shown, and Greece and Portugal in limited cases, especially those based on the model variant using the debt ratio and the early autumn 2018 vintage.

Second, model forecasts seem to point to a further decline in the differential for 2022 across all vintages. From the autumn 2018 to autumn 2019 EC vintages, some of the largest improvements were recorded for Portugal and Greece, inter alia, given better than expected fiscal performance at the time. In the most recent, spring 2020 vintage, another significant improvement (drop) in the median $i - g$ is projected for all countries for 2022, a year of growth rebound from the COVID-crisis. This owes to the fact that the forecast is conditional on the path of the exogenous variable TFP growth, for which the European Commission expects a general slump in 2020 and a recovery in 2021. This creates a seesaw effect that delivers low values in 2022, as further illustrated in Chart 3 for the case of Germany and Italy (and for all the other countries in the appendix). Both countries present roughly similar shapes for each model variant and for each vintage. Whereas autumn 2018 presented a slow and sustained raise of the differential towards the outer years of the forecast, in autumn 2019 there is an

[24] This result is broadly consistent with Barett (2018).

initial rise in 2019 as the European Commission forecasted negative TFP growth for this year. After this small increase in differential, the model corrects for a couple of years and then resumes the slow increase exhibited in the autumn 2018 vintage. The results with the spring 2020 vintage show a clear increase of the differential for 2020, due to the COVID-19 crisis captured in the model through the TFP growth forecast. The European Commission also foresees a quick rebound in this variable in 2021, explaining the immediate reduction of $i - g$ shown in the chart.

Chart 3: Median forecast for $\boldsymbol{i - g}$ with the three vintages for selected countries



Source: Authors' calculations based on real time AMECO data and forecasts (EC autumn 2018, autumn 2019 and spring 2020 forecasts). Notes: Variants 1 and 2 are panel Bayesian VARs with the short term interest rates and a fiscal variable (debt ratio in Variant 1 and primary balance ratio in Variant 2) as endogenous variables and TFP growth and dependency ratio variation as exogenous variables. The forecast starts in year 2018 for the autumn 2018 vintage, 2019 for the autumn 2019 vintage and 2020 for the spring 2020 vintage.

Third, although the forecast points to increasingly favourable differentials for 2022, on average over the period 2018-2022, the differential is projected to increase in almost all countries in the latest vintage. This owes, first, to the unanticipated (in the first two vintage) crisis effect, which brings about a large increase in the differential in 2020, only partly compensated in the next two years. The second reason is related to the upward revisions in the historical $i - g$ values in several countries across the vintages and a general tendency of the model to under-predict the differential (see more details below).

Fourth, the differential is generally projected at higher values in the high debt countries compared to the rest. The largest differential is generally projected for Italy (in the latest vintage, it is the only country with a positive differential for the period 2018-2022). Greece (inter alia, having benefitted from favourable programme and post-programme financing conditions) displays a lower differential, but as mentioned before, still positive in several model cases. Spain, France and Belgium also display higher differentials than the rest, while in Portugal the forecast has improved more recently from positive values projected in the autumn 2018 vintage.

Fifth and most importantly, as already hinted at, the model generally forecasts an increasing path of the differential towards the end of the forecast horizon, particularly in the latest vintage. As shown in Table 9, the values of $i - g$ in 2024 are higher than in 2022 for all countries. The same trend is depicted in Chart 3 and Appendix 4, with all vintages.

Although the path of the median contains a lot of information, it is useful to go beyond and study the distribution of the differential. As already pointed out, based on recent trends before the COVID-crisis, the models would estimate $i - g$ medians that are generally negative in five years. However, as suggested also by Barett (2018), there is a large uncertainty around the median estimates and the probability of positive interest rate-growth differential is non-negligible, especially in the high debt countries (see Table 10). The model average of the BVAR specifications for the entire five-year horizon across each vintage identifies four countries (Italy, Greece, Spain and Portugal[25]) with a probability of $i - g$ being above 0 greater than one third. This, together with the projected increase in the differential in the later years of the horizon, suggests caution about future developments in the differential, particularly in the highly indebted countries.

Table 10: Model average of the probability of positive $\mathbf{i - g}$ across forecast vintages

Country	Probability above 0 (forecast period)		
	EC Autumn 2018	EC Autumn 2019	EC Spring 2020
Belgium	0.18	0.17	0.23
Germany	0.20	0.23	0.25
Greece	0.50	0.45	0.44
Spain	0.33	0.38	0.35
France	0.20	0.26	0.24
Italy	0.60	0.68	0.45
Netherlands	0.15	0.11	0.21
Austria	0.20	0.14	0.21
Portugal	0.42	0.38	0.33
Finland	0.27	0.32	0.28

Source: Authors' calculations based on real time AMECO data and forecasts (EC autumn 2018, autumn 2019 and spring 2020 forecasts). Notes: Probability of positive *i-g* calculated as the share of paths that deliver a positive value during the forecast period. For further information on the models, see Table 9.

Further, we provide more details on the fit of the panel BVAR model forecast by evaluating the out-of-sample performance. Table 11 below presents the mean error (ME) of the out of sample forecast for the

[25] In Portugal, the probability above zero has declined to about one-third in the latest vintage, from higher values in the past vintages (including above those forecast for Spain, for which the model results show a deterioration across the vintages).

period 2013-2017 with the two model variants. The error is computed as the difference between the actual value (available in AMECO) and the median of the forecast computed as an out of sample forecast between 2013 and 2017 with the EC autumn 2018 vintage. In general, errors are positive, which points to some under-prediction (model predicted somewhat lower values than the actual).[26] The biggest outliers in terms of error are Germany and Portugal. Both are explainable in light of the particularly subdued differentials these countries have had compared to their history. For the forecast period 2018-2022, a comparison with the latest Ameco forecast points to very similar values. This would justify an even more cautious approach about the forecast of deeply negative values of the differential going forward.

For our back-casting period, we also verify if the choice of gross debt or primary balance as fiscal variable in the BVAR depends on the country. For most countries, the mean errors are similar across the two variants for the period 2013-2017 (though, as shown in Table 9, more substantial differences appear in individual years for the current forecast period). For the average of 2013-2017, the debt variable (variant 1) seems to provide a somewhat better estimation especially for Germany, Spain, France and the Netherlands. The biggest difference between the two models is recorded for Greece, in which the primary balance model seems to have led to lower mean errors over the past period considered.

Table 11: Mean forecast errors of $i - g$ for the 2013-2017 period

Country	**Variant 1**	**Variant 2**
Belgium	-0.6	-0.3*
Germany	2.6*	2.9
Greece	1.4	-0.4*
Spain	-0.3*	-0.5
France	0.0*	-0.2
Italy	0.5	0.4*
Netherlands	0.8*	1.0
Austria	1.0*	1.0
Portugal	2.1	2.1*
Finland	0.8*	0.8

Source: Authors' calculations based on EC Autumn 2018 data and forecast. Notes: Mean errors computed as difference between historical observations and the median of the BVAR model variants. For further information on the models, see Table 9.

[26] Data that became available after the cut-off date of our analysis point to a similar sign of the forecast error for 2018, albeit the size of the error is generally small. For almost all countries in the sample (with the notable exception of the Netherlands), the forecast error continued to be positive (*i-g* in 2018 turned out to be higher than projected). The forecast error for Germany and Portugal also turned positive (average of 0.7 *pp* for both countries).

The panel BVAR model is a statistical approach and, consequently, its results are completely dependent on the past relationships between variables and on the EC forecast of the exogenous variable TFP growth. The results of a different method are presented in Table 12. This is a (deterministic DSA) model where interest rate assumptions are based on market expectations at around the cut-off date of each EC forecast vintage, while real growth is assumed to converge towards the EC potential output growth, as projected in the same vintage. For details, see Bouabdallah, Checherita-Westphal et al. (2017), in which this model (deterministic DSA benchmark) is simulated for a period of ten years.[27]

Table 12: Deterministic model with market expectations

Country	**Autumn 2018 forecast vintage**		**Autumn 2019 forecast vintage**		**Spring 2020 forecast vintage**	
	T+5 (2022)	avg. 10 year forecast	T+5 (2023)	avg. 10 year forecast	T+5 (2024)	avg. 10 year forecast
Belgium	-0.8	-1.0	-1.4	-1.4	-1.4	-1.1
Germany	-2.8	-2.1	-2.1	-2.0	-2.5	-2.0
Greece	-0.2	-0.1	-1.2	-1.1	-0.9	-0.3
Spain	0.0	-0.5	-0.4	-0.8	-1.3	-0.7
France	-0.6	-1.0	-1.1	-1.5	-1.6	-1.4
Italy	1.4	1.1	0.5	0.5	0.0	0.6
Netherlands	-1.8	-2.1	-1.5	-1.6	-2.0	-1.4
Austria	-1.8	-1.8	-1.9	-1.7	-1.5	-1.2
Portugal	0.3	-0.1	-0.8	-0.9	-0.8	-0.3
Finland	-1.7	-1.8	-1.5	-1.7	-2.3	-1.9

Source: Authors' calculations based on Bouabdallah et al. (2017). Notes: The deterministic model is based on market expectations and potential output growth forecast at around the cut-off date of the EC forecast vintages (autumn 2018, autumn 2019 and spring 2020 forecasts), as well as an assumption of loose compliance with the SGP minimum requirements (beyond the EC forecast horizon), as described in Bouabdallah et al. (2017).

Comparing the results for the last year of the T+5 forecast in the two methods, we generally note the same sort of benevolent $i - g$ conditions. Whereas with the 2018 and 2019 EC forecast vintages, the two models provide relatively close estimates for T+5, with the spring 2020 vintage, the deterministic model, which fully incorporates the EC forecast until 2021 foresees a higher differential than the panel BVAR model (by 0.6 percentage points on average for the sample).[28] Going beyond the 5-year horizon, this model also generally forecasts an increase in the differential towards the end of the forecast horizon at T+10, on the assumption that countries follow a path of loose compliance with SGP rules, i.e. countries below their MTOs would take additional consolidation measures to gradually reach the

[27] We are grateful to O. Bouabdallah and S. Pesce for support in running the model with the three forecast vintages.

[28] Conversely, the BVAR forecasts higher differentials for T+5 in the autumn 2018 forecast (by 0.5 pp. on average for the sample). It also forecasts a slightly higher differential on average for the autumn 2019 vintage (by 0.2 pp.).

MTO, after allowing for the margin of deviation. Another assumption of this deterministic DSA benchmark scenario is the absence of another crisis over the simulation horizon. Thus, on average over the 10-year horizon, the interest rate-growth differential is generally projected to be negative for all countries apart from Italy. Nonetheless, under the latest vintage following the COVID-crisis, the forecasted 10-year average is higher, after having seen an improvement for most countries between the autumn 2018 and 2019 vintages.

Overall, the proposed panel BVAR model, as well as the sensitivity analysis with the deterministic DSA model, point to the fact that the interest rate-growth differential will generally increase, albeit remaining negative for most euro area countries considered. The probability of positive $i - g$ values is non-negligible, especially in high debt countries. Finally, the BVAR estimates by country should be regarded with caution, especially under the current circumstances, when the consequences of the COVID-19 crisis are difficult to predict.

IV. Conclusions and areas for future research

This paper contributes to the empirical literature by providing a thorough investigation of the topic of interest rate-growth differential on government debt across euro area countries.

We first provide stylised facts for the interest rate-growth differential in the euro area before the COVID-19 crisis. The negative differentials prevailing at that time in most mature euro area countries (and other advanced economies) have been well below recent historical averages. Such long-term historical averages since the early 1980s or the EMU period remain positive in most high income, mature economies, and hover around 1 percentage point. In the context of recent discussions on secular stagnation, each of the components of the differential has followed a protracted downward trend. Real interest rates in advanced economies have declined since the 1980s and, in the wake of the global financial crisis, plummeted to exceptionally low levels. At its turn, potential output growth has also dropped, with the differential following a less pronounced decline and showing no apparent trend until more recently.

We also review the existing literature and conclude that most of the theoretical and empirical evidence so far points to an expected increase in the interest-growth rate differential in the euro area from the current negative territory.

In our empirical analysis, we first investigate the macroeconomic, financial, demographic and institutional determinants of $i - g$ across euro area countries. While we control for many relevant variables and conduct a variety of robustness checks (across countries, periods and estimators, with lagged explanatory variables and GMM dynamic panel models to control for endogeneity), given the highly endogenous nature of these factors, our analysis unveils mostly correlations, with causation likely to work both ways in many instances.

We find that countries with a higher public debt burden, higher primary deficits or an increase in public debt are more likely to have a higher interest rate-growth differential (even after controlling for the position in the economic cycle). The differential tends to increase significantly in bad economic times, which signals that any deviations from the currently good economic conditions may quickly bring $i - g$ into positive territory. For the euro area period (1999-2017), monetary policy loosening is associated with a lower differential. Equivalently, a monetary policy tightening, proxied by an increase in the short-term interest rate and other monetary policy interest rates or a decline in monetary policy assets, would induce an increase in the interest rate-growth differential on government debt. On the other hand, technological progress or any other factors that increase TFP growth promote a decrease in $i - g$.

The impact of ageing is more difficult to disentangle as the two variables controlled for are inter-related. A higher dependency ratio is associated with lower $i - g$, while slower population growth tends to increase the differential. This result could be justified in so far that ageing induces predominantly a higher saving-lower interest rate configuration, while lower population growth may have a more pronounced and quicker effect on growth than on interest rates.

As to the impact of other variables, there is some evidence that the global saving glut hypothesis is associated not only with a decline in interest rates, but also in the interest rate-growth differential. With respect to various time events, after controlling for the relevant macroeconomic and financial variables, the one-off introduction of the euro seems to have promoted some decline in the interest-rate growth differential, which seems to have originated from the reduction in the implicit interest rate. Regarding the effect of the financial and sovereign debt crisis, when used alone in the regression for the entire period, the crisis dummy (post-2007) is positive and statistically significant. That is, the interest rate-growth differential since the financial crisis has been much higher, on average, than before (1985-2007). However, controlling for other relevant factors, it appears that the post-crisis differential has actually been statistically significantly *lower* than before.

In general, our results for the euro area sample are in line with others in the literature for the larger group of advanced economies. In particular, as found in Escolano et al. (2017) or Turner and Spinelli (2011), more vulnerable fiscal positions are found to be associated with higher differentials. As per the later study, we also find some evidence for the global saving glut hypothesis and declining differential over the euro area period. We look into more details at the variables associated with monetary policy:

while we do not find an impact stemming from the slope of the yield curve as in Turner and Spinelli, we do find a significant impact of various monetary policy instruments over the euro area period.

Finally, we present forecasts for $i - g$ over the medium-term (5-year horizon) with a panel Bayesian VAR model with hierarchical prior (with two different specifications according to the fiscal variable chosen, debt or budget balance). The model is run based on data across three different EC forecast vintages. We start with the EC autumn 2018 forecast vintage (and the historical period 1999-2017 used in the previous empirical analysis), continue with the 2019 autumn vintage and finally show results using the EC spring 2020 forecast, which includes the projected impact at the time of the COVID-19 pandemic. In addition, we conduct a sensitivity analysis with a deterministic DSA forecast model, in which the interest rate assumptions are based on market expectations and real growth is assumed to converge towards EC potential growth projections. In general, the model forecasts must be interpreted with caution, particularly at the current juncture, given the high uncertainty surrounding the still on-going crisis, which has drastically affected both economic and financial conditions.

The following conclusions can be drawn based on these forecast exercises for the considered EA-10 sample. First, the differential is generally projected to remain negative over the medium-term across the various forecast vintages. Moreover, the model forecasts seem to point to a further decline in the differential for the year 2022 across the three vintages considered. Yet, there are also reasons to be cautious with these conclusions. Most importantly, for the high debt countries, both the median forecast and the probability of positive interest rate-growth differential are generally higher compared to the low debt countries. The model average of the BVAR specifications for the entire five-year horizon identifies four countries (Italy, Greece, Spain and Portugal) with a probability of $i - g$ being above 0 greater than one third. Further, albeit the forecast points to increasingly favourable differentials for 2022, on average over the period 2018-2022, the differential is projected to increase in almost all countries in the latest vintage. This owes to the COVID-19 crisis effect, which brings about a large increase in the differential in 2020, and to a general tendency of the models to somewhat under-predict the differential. Finally, the models generally forecast an increasing path of the differential towards the end of the forecast horizon.

Overall, while $i - g$ is projected to remain well below its historical average over the medium term according to these models, the analysis advise caution, especially for the high debt countries. Whereas effective public spending and investment can lift a country's medium-term growth potential and mitigate the negative cyclical effects of a downturn, particularly in an environment of low interest rates for long, currently high debt burdens in many economies remain a source of vulnerability. As emphasised in Giavazzi (2017), relying on $i < g$ as a substitute for reforms is a risky proposition.

Appendices

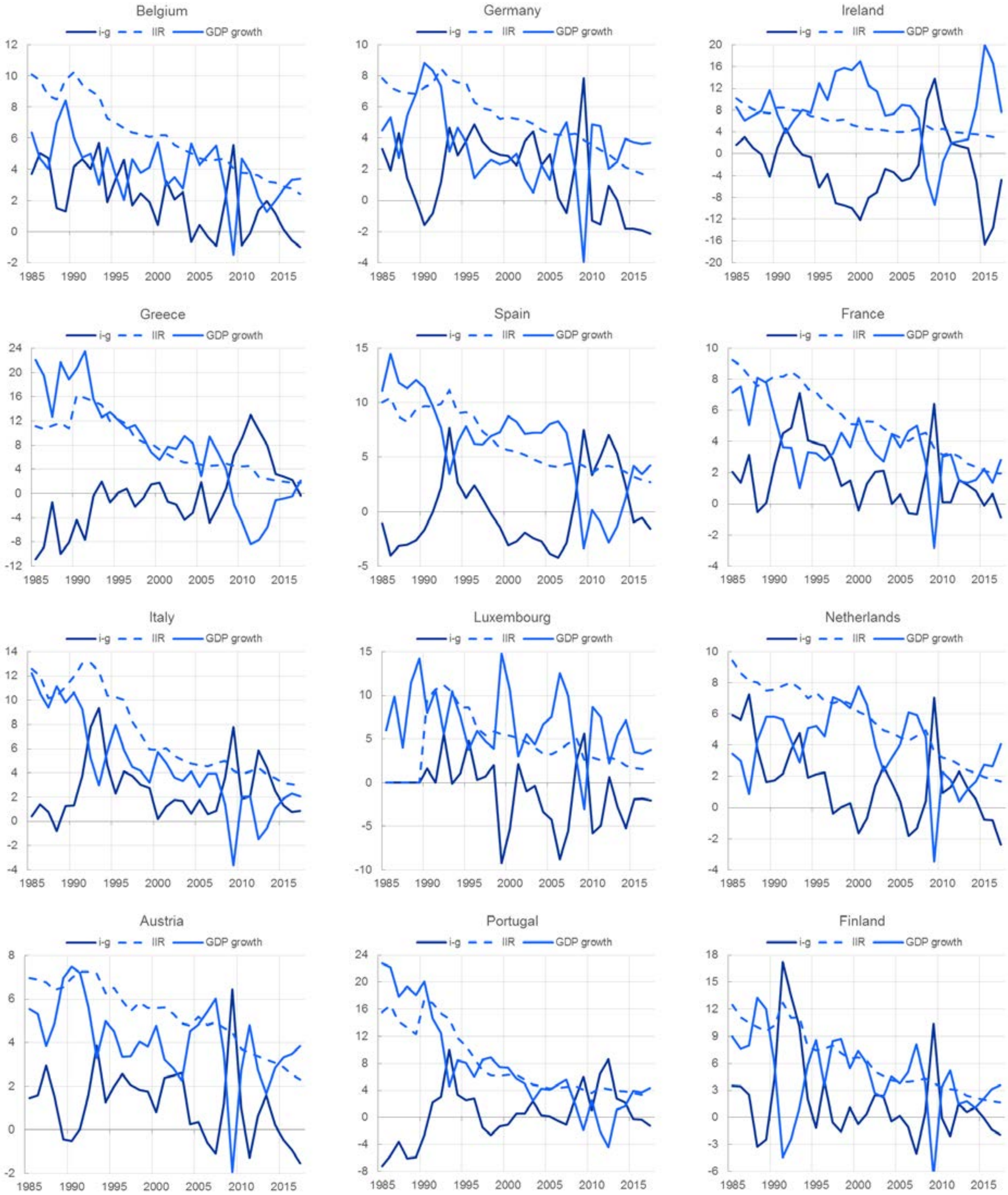
Appendix 1: Further stylised facts about $i - g$

Table A1: Mean $i - g$ and components over the given historical periods

	1970-2017			1985-2017			1999-2017		
	i-g	IIR	GDP growth	*i-g*	IIR	GDP growth	*i-g*	IIR	GDP growth
BE	1.2	6.9	5.5	2.0	6.1	4.0	1.0	4.3	3.4
DE	1.2	5.8	4.5	1.7	5.2	3.5	1.1	3.7	2.6
IE	-3.6	6.9	10.8	-1.7	5.6	8.1	-1.8	4.1	7.3
GR	-	-	11.5	-0.3	7.7	8.0	2.3	4.4	2.1
ES	-3.6	6.0	9.4	0.2	6.3	6.2	0.2	4.3	4.1
FR	0.6	5.9	6.3	1.8	5.4	3.7	0.9	3.8	2.8
IT	-1.2	7.6	8.6	2.6	7.2	4.6	2.3	4.5	2.3
LU	-	-	7.4	-1.3	5.0	6.7	-2.7	3.4	6.1
NL	1.7	6.2	5.3	1.6	5.5	3.9	0.6	3.9	3.4
AT	0.0	5.6	5.5	1.1	5.2	4.1	0.8	4.2	3.4
PT	-2.2	8.8	11.6	0.5	8.1	7.6	1.5	4.5	3.0
FI	0.0	7.5	7.4	1.8	6.3	4.5	0.5	3.8	3.4
EE	-	-	6.4	-6.5	4.1	9.3	-5.3	3.4	8.7
CY	-	-	8.6	0.3	4.7	6.5	0.4	4.6	4.2
LV	-	-	6.5	-3.9	5.7	9.4	-3.6	5.2	8.9
LT	-	-	5.9	-2.6	5.8	8.5	-1.3	5.4	6.7
MT	-	-	8.4	-0.6	5.5	7.0	-0.8	5.4	6.2
SI	-	-	5.1	0.3	7.0	7.5	0.6	6.2	5.7
SK	-	-	4.9	-1.0	5.9	7.1	-1.1	5.3	6.4
DK	3.1	9.3	6.1	3.3	7.2	3.9	1.8	5.0	3.2
UK	-1.0	7.1	7.9	1.2	6.5	5.3	0.8	4.7	3.9
SE	-0.6	6.5	6.9	0.4	5.6	5.2	-0.8	3.4	4.2
JP	1.1	3.2	4.3	1.0	2.8	1.8	1.0	1.2	0.2
US	1.9	8.3	6.3	2.0	6.9	4.9	1.0	5.1	4.1

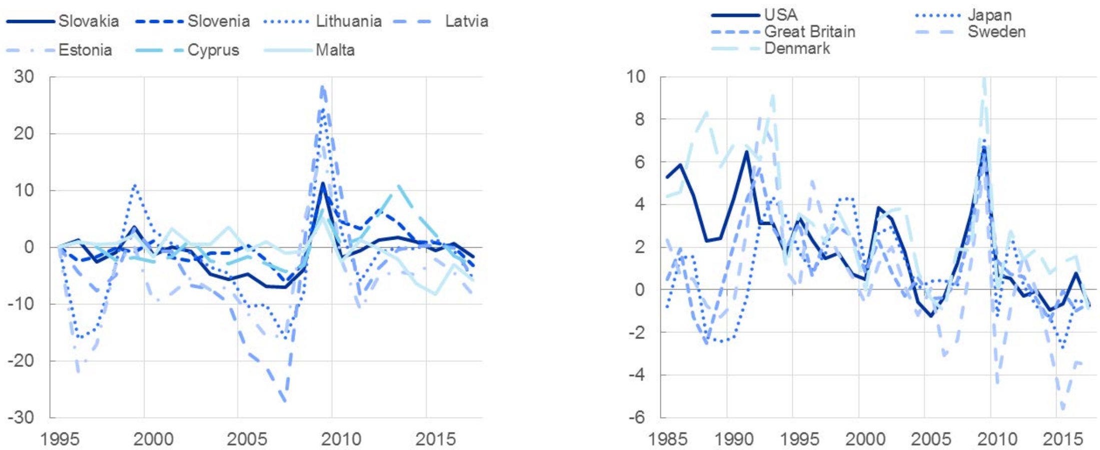
Source of data: Ameco (and other sources; see Appendix 5).

Chart A1: Implicit interest rate on government debt (IIR), nominal GDP growth and their differential in EA-12 countries, 1985-2017



Source of data: Ameco (and other sources; see Appendix 5)

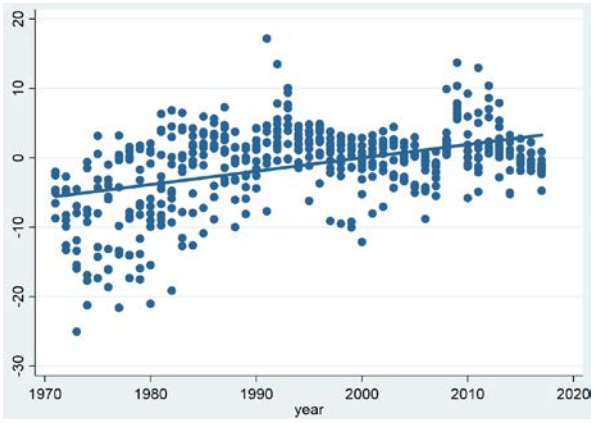
Chart A2: Historical interest rate-growth differential for other advanced economies



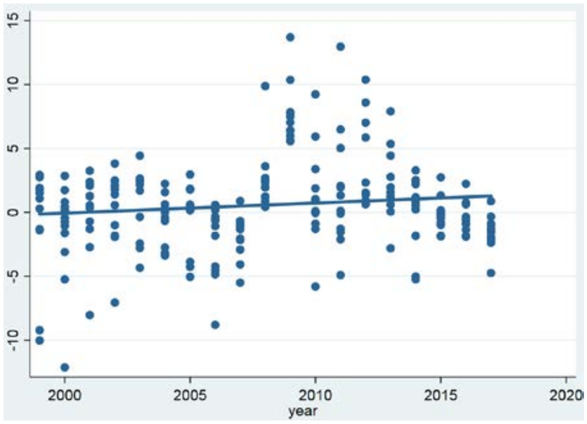
Source of data: Ameco (and other sources; see Appendix 5)

Chart A3: Historical interest rate-growth differential trend for EA-12 countries in two periods

1970-2017



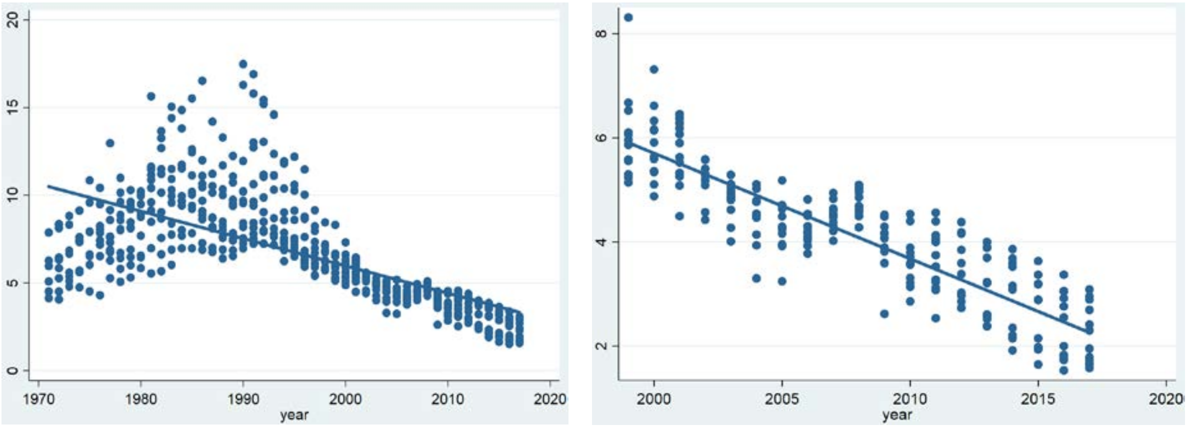
1999-2017



Source of data: Ameco (and other sources; see Appendix 5)

Chart A4: Historical implicit interest rate trend for EA-12 countries in two periods

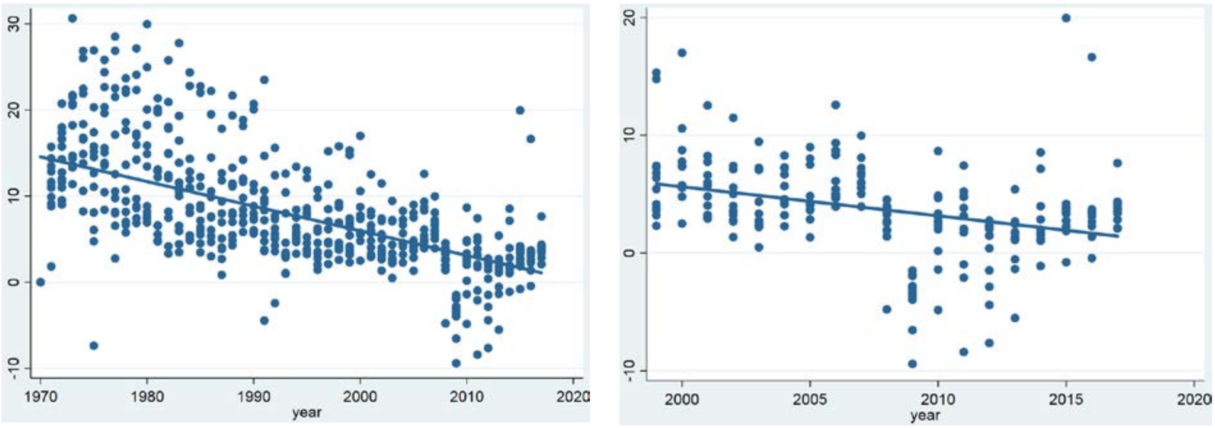
1970-2017 **1999-2017**



Source of data: Ameco (and other sources; see Appendix 5)

Chart A5: Historical nominal growth trend for EA-12 countries in two periods

1970-2017 **1999-2017**



Source of data: Ameco (and other sources; see Appendix 5).

Table A2: Time trend of $i - g$ and components over the given historical periods

	1970-2017			1985-2017			1999-2017		
	i-g	IIR	GDP growth	*i-g*	IIR	GDP growth	*i-g*	IIR	GDP growth
BE	0.0517	-0.144***	-0.170***	-0.135***	-0.242***	-0.107***	-0.0911*	-0.208***	-0.0860***
DE	0.0178	-0.124***	-0.121***	-0.102*	-0.200***	-0.0979**	-0.318***	-0.222***	-0.0976
IE	0.219***	-0.182***	-0.260**	0.0245	-0.193***	-0.085	0.635*	-0.0914***	-0.138
GR	-	-	-0.544***	0.407***	-0.415***	-0.822***	0.407*	-0.313***	-0.849***
ES	0.385***	-0.0543*	-0.387***	0.101	-0.256***	-0.357***	0.330*	-0.145***	-0.314***
FR	0.103	-0.179***	-0.273***	-0.0832**	-0.229***	-0.146***	-0.0383	-0.204***	-0.0830**
IT	0.355***	-0.131***	-0.434***	0.00138	-0.335***	-0.336***	0.0661	-0.161***	-0.277***
LU	-	-	-0.105	-0.178***	-0.326***	-0.150***	0.102	-0.210***	-0.148**
NL	-0.0657	-0.189***	-0.165***	-0.145***	-0.230***	-0.0846*	-0.0192	-0.272***	-0.161***
AT	0.108**	-0.0767***	-0.159***	-0.0513	-0.147***	-0.0954***	-0.131***	-0.189***	-0.103**
PT	0.424***	-0.313***	-0.517***	0.178*	-0.454***	-0.631***	0.131	-0.153***	-0.463***
FI	0.127*	-0.215***	-0.302***	-0.162	-0.340***	-0.178**	-0.0607	-0.265***	-0.0517
EE	-	-	0.262***	0.41	-0.366***	0.036	0.17	-0.326***	-0.362
CY	-	-	-0.268**	0.223	-0.144***	-0.359***	0.314	-0.192***	-0.386***
LV	-	-	0.246**	0.271	-0.280***	-0.019	0.319	-0.270***	-0.456
LT	-	-	0.224***	0.269	-0.209***	-0.014	-0.0976	-0.202***	-0.407
MT	-	-	-0.137	-0.306***	-0.153***	-0.043	-0.401***	-0.186***	-0.0413
SI	-	-	0.153**	0.186	-0.440***	-0.147	0.185	-0.394***	-0.577*
SK	-	-	0.170***	0.0716	-0.385***	-0.06	0.131	-0.361***	-0.416**
DK	-0.0489	-0.311***	-0.226***	-0.182***	-0.298***	-0.116***	-0.0674	-0.212***	-0.0862**
UK	0.201***	-0.130***	-0.290***	-0.0455	-0.248***	-0.202***	-0.106**	-0.208***	-0.113***
SE	0.0515	-0.172***	-0.192***	-0.151**	-0.306***	-0.155**	-0.214**	-0.279***	-0.0697
JP	-0.0152	-0.206***	-0.294***	-0.0169	-0.199***	-0.182***	-0.211***	-0.0818***	-0.0969
US	-0.0273	-0.202***	-0.148***	-0.148***	-0.261***	-0.113***	-0.110*	-0.238***	-0.0955***

Source: Ameco (and other sources; see Appendix 5). Notes: the table shows results from country-specific regressions of the variable shown and a time trend. Significance level: *** p<0.01, ** p<0.05, * p<0.1.

Appendix 2: Interest rate-growth differential in an endogenous growth model

The model[29] starts from an infinitely lived representative agent with preferences over consumption, C, defined by the utility function:

$$V = \int_0^\infty (C^{1-\sigma} - 1)/(1-\sigma)e^{-\rho t}dt$$

where σ is the inverse of the intertemporal elasticity of substitution (or the net response of the growth rate of consumption to the real interest rate), and ρ is the agent's rate of time preference.

Output can be given by a simple function of (private) capital as in the AK model or it can be expanded as in Aschauer (2000) to include public capital stock, that is:

$$Y = [L^\beta K^{1-\beta}]^{1-\alpha} K_g^\alpha$$

where L= labour, K = private capital, and Kg = public capital. There are constant returns to scale between private inputs as a group and the public input. As such, the economy is capable of endogenous growth.

Government will have to levy a tax on output at a rate θ to cover the interest on its debt *(rb)* and finance new public investment (ΔK_g), while the existing public capital stock has been financed by the stock of government debt *(b)*. In the standard growth model, there is only one (real) interest rate in the economy *(r)*. The government's budget constraint is therefore:

$$\Delta b = rb + \Delta K_g - \theta Y$$

The private agent meanwhile maximise lifetime utility subject to its resource constraint (abstracting from the depreciation rate). $\Delta K + \Delta b + C = (1-\theta)Y + rb$

The steady state growth rate of this economy follows from the typical maximisation problem of the economic agent's lifetime utility, subject to the resource constraint. In the steady-state, output, as well as consumption, public and private capital with grow at the same rate given by:

$$\gamma = \frac{(1-\theta)(1-\alpha_{kg})\left(\frac{K}{K_g}\right)^{\alpha_{kg}} - \rho}{\sigma} = \frac{(1-\theta)MPK - \rho}{\sigma}$$

In the standard model, the steady state growth rate (γ) is proportional to the difference between the after-tax $(1-\theta)$ marginal product of private (as well as public) capital (MPK) and the rate of time preference (ρ).

This is a variant of the Ramsey rule (and the neoclassical growth model) describing optimal evolution of consumption, abstracting from taxes and considering the depreciation rate of capital (δ):

[29] This Appendix draws from the ECB working paper version of Checherita-Westphal, Hughes-Hallet and Rother (2014), which presents a growth model to determine maximising levels of public capital and debt, based on Aschauer (2000).

$$\frac{\dot{c}}{c} = \frac{MPK - \delta - \rho}{\sigma}$$

From the first order conditions, it also follows that the real interest rate must equal the after-tax marginal product of private capital $r = (1 - \theta)MPK$. Therefore, along the balanced growth path, the real output growth rate (γ) equals:

$$\gamma = \frac{r - \rho}{\sigma}$$

As shown in Turnovsky (2010), this result holds in all model variants from a closed-economy AK model a la Barro (1990) to an open small economy, where the growth rate depends on the difference between the (given) foreign interest rate and the rate of time preference.

In terms of our notation for the (real or nominal) interest rate-growth differential on the economy-wide and on government debt, we obtain:

$$i - \sigma g = \rho,$$

Or with a positive (non-zero) capital depreciation rate: $i - \sigma g = \rho + \delta$

Since the rate of time preference or the discount rate is generally assumed to be strictly positive $(\rho > 0)$ and σ, the inverse of the elasticity of intertemporal substitution (EIS), [30] to be higher than one, then $i - g$ for an economy along its balance growth path is strictly positive. In equilibrium, its size is larger the larger the rate of time preference (the discount rate) and the capital depreciation rate and the smaller the elasticity of intertemporal substitution.

Equivalently, as shown in Blanchard and Fischer (1989) and Turnovsky (2010), to be viable (non-exploding), the long-run equilibrium must satisfy the transversality conditions requiring that the after-tax marginal return of capital or the real interest rate is larger than the real growth of the economy: $(1 - \theta)MPK > \gamma \leftrightarrow r > \gamma$.

In a growth model with private and public capital, two transversality conditions need to be met to avoid exploding equilibria: the limit of the present value of both private capital per worker and public debt should be zero (thus ruling out Ponzi-schemes). Given the golden rule of government financing assumed in the model $K_g = b$, it also follows that the tax rate needed to service the debt in the long term and to ensure minimum conditions for sustainability depends on the real interest rate and is given by $\theta = r\phi^{1-\alpha}$, where $\phi = K_g/L^{\beta}K^{1-\beta}$ is the public to private inputs ratio.

[30] Havranek (2015), a meta-analysis of 169 published studies, concludes that the published literature estimating EIS is consistent with the elasticity being positive and lying deep below 1. Corrected for the reporting bias, the micro estimates are found to be around 1/3, while many macro studies report results of 0.5 or close to 1. Even with EIS=1 ($\sigma = 1$), that is, the the growth rate of consumption responds one-to-one to changes in the real interest rate, then $i - g = \rho + \delta > 0$

Appendix 3: Robustness across various empirical estimators

The results of the base specification remain generally robust to the choice of several empirical estimators, in particular, the Arellano-Bond dynamic panel estimator intended to better control for endogeneity, as well as dynamics effects. Yet, such an indicator is suited for panels with short time dimension (T) and large cross-sectional units (N), which is not the case of our dataset. Table A3 below summarises the results. Model 1 shows the fixed-effects estimator with robust standard errors; Model 2 - the random effect estimator, controlling in addition for time fixed effects; Model 3 - the Prais-Winsten regression estimator with standard errors corrected for panel correlation; while Models 4-7 show results with Arellano Bond GMM estimator with robust standard errors (adjusted for clustering on countries) for our two main periods of reference as indicated in the table header and replacing debt level and primary balance (from models 4 and 5) with the change in debt (models 6 and 7). The latter variable is generally more robust in the Abond specifications.

Table A3: Robustness across various estimators (EA-12)

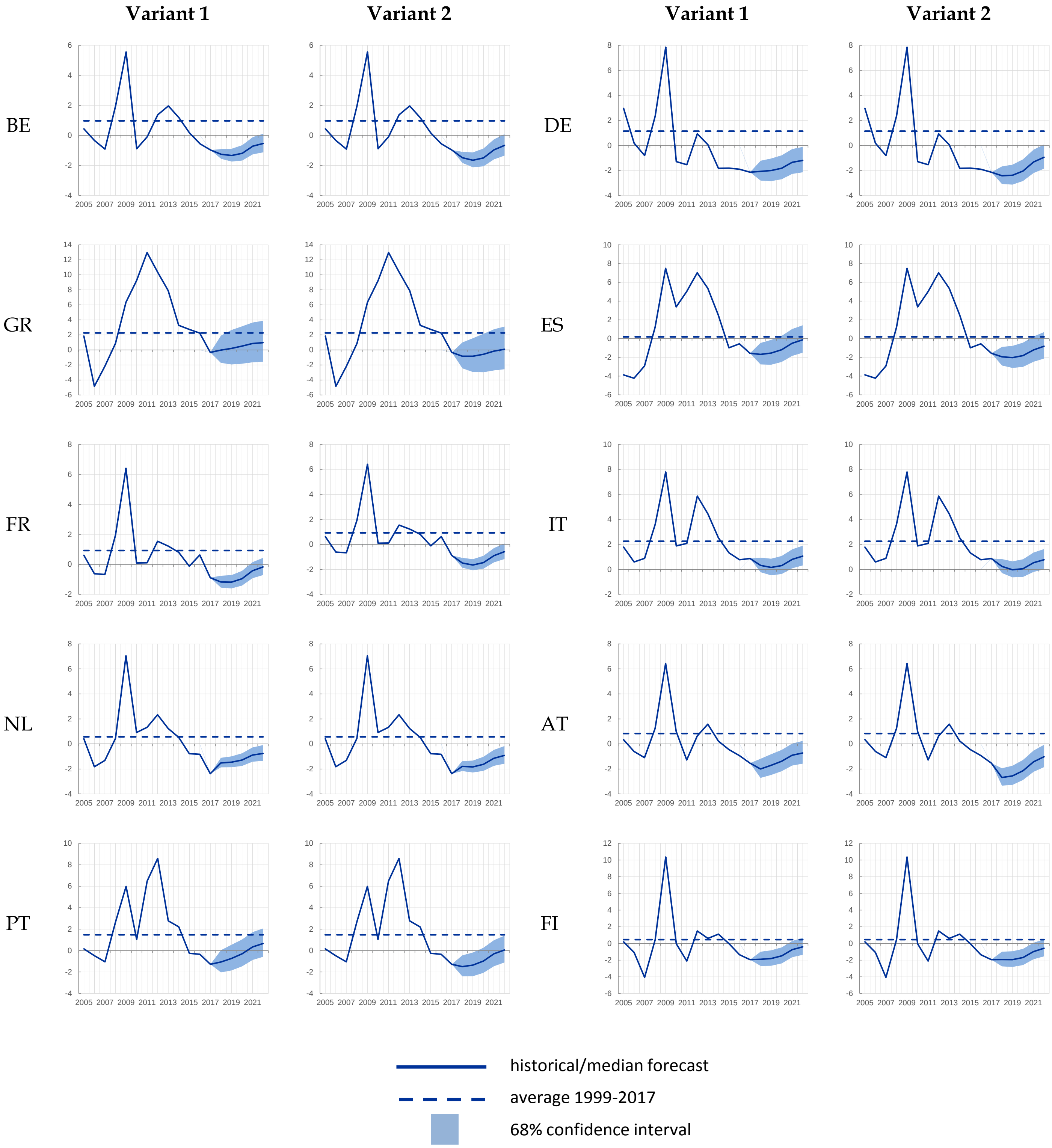
MODEL/ VARIABLES	**Model 1** Fixed-effects, robust SE	**Model 2** Random-effects, robust SE (time FE)	**Model 3** Prais-Winsten estimator (country & time FE)	**Model 4** Arellano-Bond, robust SE	**Model 5** Arellano-Bond, robust SE	**Model 6** Arellano-Bond, robust SE	**Model 7** Arellano-Bond, robust SE
	1999-2017	1999-2017	1999-2017	1985-2017	1999-2017	1985-2017	1999-2017
Government debt ratio	0.0313***	0.0209**	0.0362**	0.0137*	0.0248**		
	(0.00965)	(0.00936)	(0.0168)	(0.00795)	(0.0104)		
Primary balance ratio	-0.221***	-0.132*	-0.159***	-0.0683	-0.179***		
	(0.0496)	(0.0799)	(0.0568)	(0.0495)	(0.0507)		
Change in government debt						0.122***	0.147***
						(0.0283)	(0.0323)
Output gap	-0.347***	-0.333**	-0.328***	-0.0879	-0.238***	-0.0966	-0.263***
	(0.106)	(0.146)	(0.0853)	(0.0696)	(0.0758)	(0.0774)	(0.0480)
Current account balance (private)	0.0438	0.0699*	-0.00066	-0.102**	0.0116	-0.120***	0.0243
	(0.0417)	(0.0414)	(0.0483)	(0.0408)	(0.0379)	(0.0360)	(0.0356)
TFP growth	-0.815***	-0.958***	-0.727***	-0.976***	-0.867***	-0.860***	-0.774***
	(0.0831)	(0.177)	(0.0933)	(0.0639)	(0.0933)	(0.0783)	(0.0879)
Dependency ratio	-0.466***	-0.0754	-0.565***	-0.152**	-0.376***	-0.110*	-0.307***
	(0.0999)	(0.101)	(0.127)	(0.0671)	(0.0896)	(0.0573)	(0.0663)
Population growth	-1.122**	-1.329***	-1.278**	-1.304***	-1.308***	-1.461***	-1.498***
	(0.503)	(0.422)	(0.526)	(0.313)	(0.486)	(0.352)	(0.517)
Short-term interest	0.283***	-0.197	0.375**	0.0450	0.234***	0.00507	0.114**
	(0.0535)	(0.235)	(0.183)	(0.0391)	(0.0720)	(0.0321)	(0.0570)
(i-g) US	0.221***			0.348***	0.183***	0.319***	0.155***
	(0.0675)			(0.0818)	(0.0522)	(0.0866)	(0.0601)
(i-g) L1.				0.466***	0.258***	0.431***	0.242**
				(0.0720)	(0.0930)	(0.0721)	(0.0977)

(i-g) L2.				0.0443	-0.102***	0.0626	-0.0641**
				(0.0351)	(0.0277)	(0.0385)	(0.0261)
Observations	226	226	226	366	225	366	225
Number of countries	12	12	12	12	12	12	12
R2	0.825						
Abond AR(2) test - pvalue				0.569	0.118	0.187	0.644
Abond AR(3) test - pvalue				.	0.949	0.824	0.334
Abond Sargan test - pvalue				1.000	1.000	1.000	1.000

Notes: Standard errors in parentheses. Significance level: *** p<0.01, ** p<0.05, * p<0.1. All models run for the EA-12 sample.

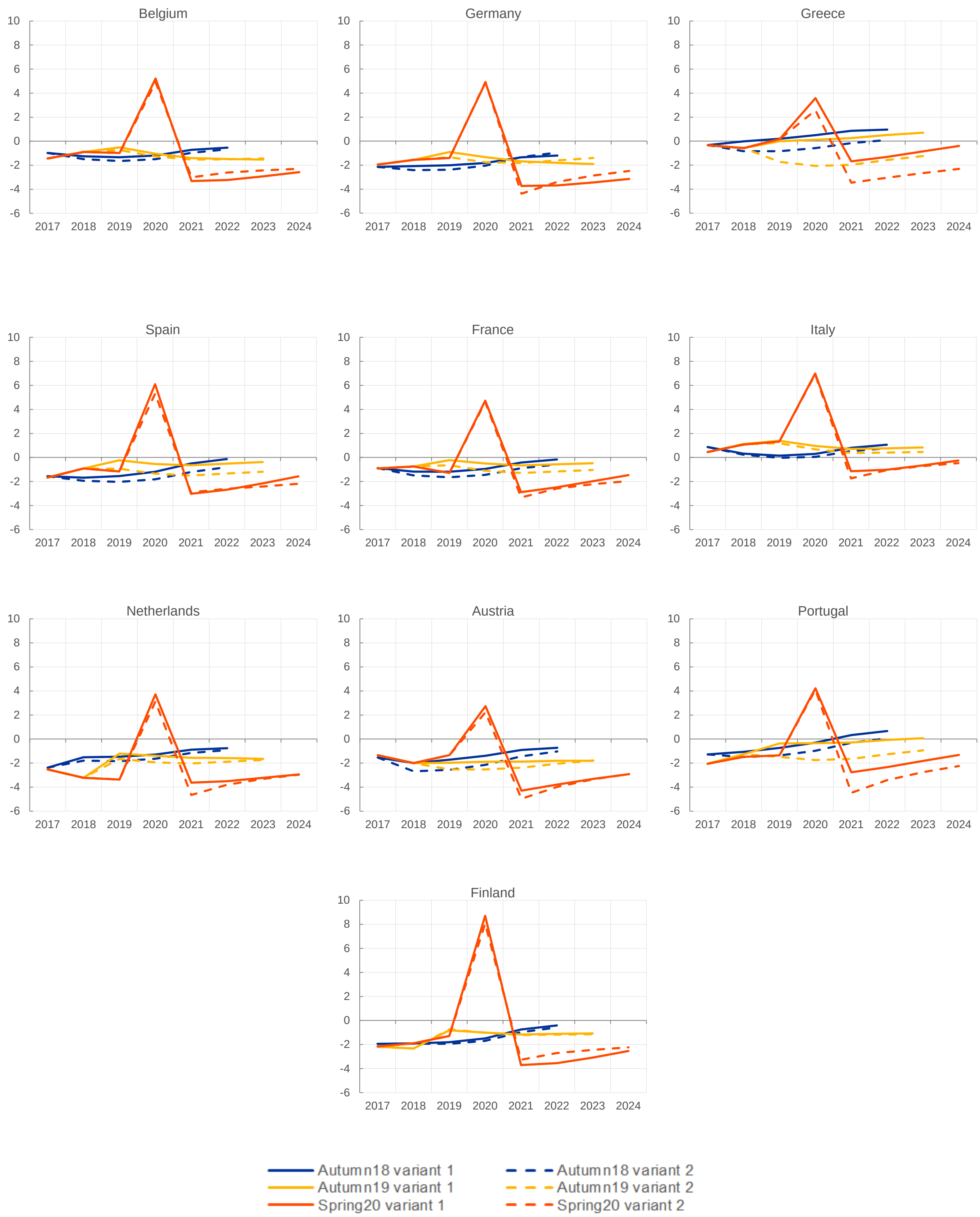
Appendix 4: Panel VAR forecast for $i - g$ over the 2018-2022 period

Chart A6: Panel VAR forecast for $i - g$ over 2018-2022 based on the EC Autumn 2018 vintage data



Source: Authors' calculations. Notes: See the text for model description.

Chart A7: Panel VAR forecast for $i - g$ based on different Ameco vintages



Source: Authors' calculations. Notes: See the text for model description.

Appendix 5: Data sources and description

The table below contains the sources used for each series as well as an indication of the date range coverage (which might differ for each country).

Variable	Source (and first available year for most EA12 countries and advanced economies)	Unit	Notes
	Fiscal variables		
Government interest payments	Ameco (1995), OECD (1980) and World Bank (1980)	Millions of euros	For countries that entered the Euro Area after 1999 the coverage starts from about 1995
Government budget balance	Ameco (1985)	Millions of euros	For countries that entered the Euro Area after 1999 the coverage starts from about 1995
Government consolidated gross debt	Ameco (1970)	Millions of euros	ES only available since 1995
	Monetary policy-related variables		
Short term interest rates (3 months)	Bloomberg/Reuters (2000), IMF(1975) and OECD (1977)	percentage	Availability in IMF and OECD vary widely among countries
Euribor	Ameco	percentage	
Long term interest rates (10 years)	Ameco	percentage	
Deposit facility rate, Marginal lending facility rate, monetary policy assets	ECB	percentage	
PSPP	ECB	Millions of Euros	
	Macroeconomic variables		
Nominal GDP	Ameco (1970)	Millions of Euros	
Output gap	Ameco (1970)	% of Potential GDP	
TFP	Ameco (1970)	-	
Current account data	IMF (1980)	Millions of Dollars	
	Demographics variables		
Population	Ameco (1970)	Thousands	
Dependency ratio	Ameco (1980), World Bank (1970)	percentage	FR only available from 1995 in AMECO
	Governance quality variables		
Corruption perception index	Transparency international (2011)	-	
Control of corruption, Political stability, Regulatory quality, Government effectiveness, Voice and accountability, Rule of law	World Bank (2002)	-	

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Cristina Checherita-Westphal
European Central Bank, Frankfurt am Main, Germany; email: cristina.checherita-westphal@ecb.europa.eu

João Domingues Semeano
European Central Bank, Frankfurt am Main, Germany; email: joao.semeano@ecb.europa.eu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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