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Determinants of long-term interest rates

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Abstract

The nominal long-term interest rate decreased in the past decades due to the decrease in (expected) inflation and in potential growth and due to changes in the age structure of the population. This conclusion is based on our survey of the literature and our empirical findings for the long-term interest rate in high-income countries since 1990. The relationship between nominal interest rates and macroeconomic fundamentals is relatively weak, as demonstrated by the low explanatory power of our regression analysis. The consensus is that the interest rate will somewhat recover, but not return to historical levels.

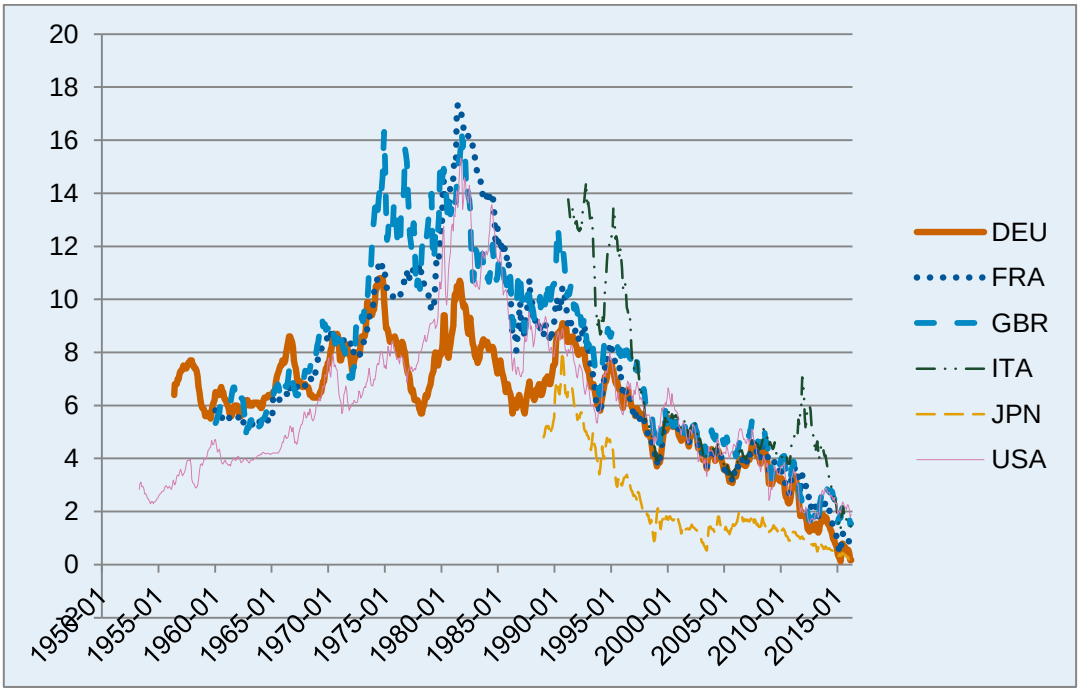
Samenvatting

De nominale lange rente is de afgelopen decennia gedaald door de afname in de (verwachte) inflatie en in de potentiële groei en door veranderingen in de samenstelling van de bevolking. Deze conclusie is gebaseerd op ons literatuuroverzicht en de resultaten van ons empirisch onderzoek naar de lange rente in ontwikkelde landen sinds 1990. De relatie tussen de nominale rente en de onderliggende macro-economische variabelen is vrij zwak, getuige de beperkte verklaringskracht van onze regressieanalyse. De consensus is dat de rente enigszins zal herstellen, maar voorlopig niet zal terugkeren naar historische niveaus.

1 Introduction

Nominal interest rates have been on a downward trend since the start of the 1980s, as illustrated by the decline in ten-year government bond rates in Figure 1.1. The low interest rate of the past few years plays a pivotal role in the economy. While it encourages debt financing for both public and private investment, it indicates a low expected return on investments and hence low discount rates. The resulting surge in discounted liabilities of pension funds and insurers has impaired their funding ratios. As a consequence, participants in defined benefit pension systems were forced to pay higher contribution rates or were faced with lower indexation rates or even cuts.

Figure 1.1 Nominal yield on 10-year sovereign bonds (%)

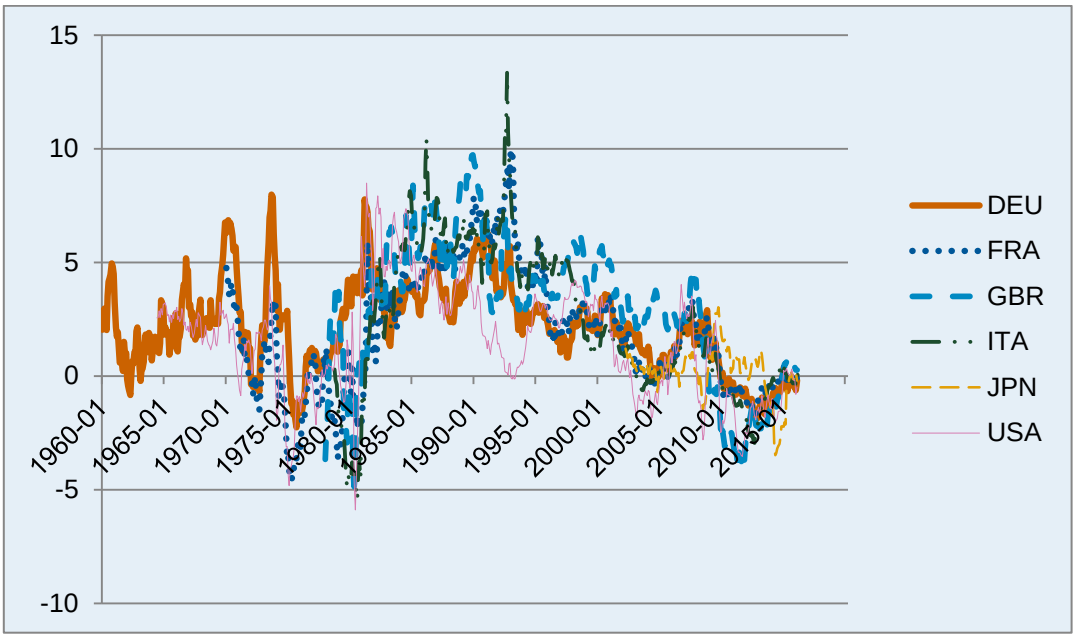


Source: OECD, https://data.oecd.org/interest/long-term-interest-rates.htm

Not only nominal rates are low now. Even when taking the low inflation rate into account, real rates turn out to be low though not exceptionally low from a historical perspective. Figure 1.2 shows that real rates were also low in the second half of the 1970s. However, this episode was associated with a higher inflation rate due to the oil crisis. Figure 1.3 indicates that the current period is unique in the sense that nominal rates, inflation rates, and real rates are all low.

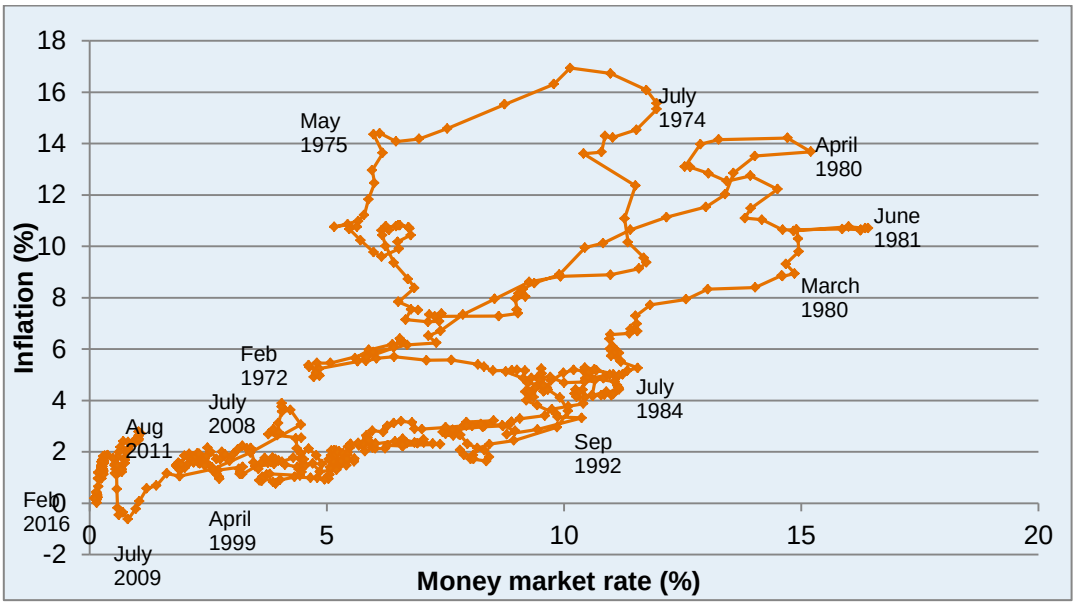
The purpose of this paper is to identify the determinants of long-term nominal interest rates, in order understand why these rates are low and to determine whether they are likely to remain low in the future. We will start with a review of the literature and then perform an empirical analysis.

Figure 1.2 Ex-post real money market rate (%)



Source: OECD https://data.oecd.org/interest/short-term-interest-rates.htm, https://data.oecd.org/price/inflation-cpi.htm

Figure 1.3 Money market rate and inflation, cross-country averages 1970-2016



Source: OECD https://data.oecd.org/interest/short-term-interest-rates.htm, https://data.oecd.org/price/inflation-cpi.htm
Included countries: France, Germany, United Kingdom, Italy, Japan, and Unites States

Using an empirical framework, we identify the determinants of the interest rates for a sample of twenty advanced economies. We consider 10-year nominal sovereign bond yields since (*i*) 10-year sovereign bonds are highly liquid, (*ii*) the downward shift in 10 year rates is representative for the downward shift of the whole term structure of

sovereign bonds,[1] and (iii) short-term yields are not suitable for our long-run focus since short-term yields are heavily affected by monetary policy.

The long-run relation between 10-year sovereign bond yields and macroeconomic fundamentals can break down in the short-run. During periods of financial stress, sovereign bond yields can temporarily deviate from their long-run equilibrium level due to cyclical factors such as short-lived panics. This motivates us to distinguish between long-run and short-run determinants of bond yields. More specifically, our baseline model uses the panel cointegration methodology employed in Poghosyan (2014) instead of the fixed effects estimator employed in the vast majority of existing studies. The panel cointegration methodology has two main advantages over the fixed effects panel data model. First, we allow sovereign interest rates to deviate temporarily from their long-run equilibrium levels. We can assess the speed of adjustment towards long-run equilibrium levels. Second, the methodology allows for country-specific short-run effects and common long-run effects. This assumption is in line with theoretical predictions and our methodology allows to test whether these predictions hold in practice.

The contribution of our paper to Poghosyan (2014) is fourfold. First, we include a variable to assess the impact of demographics on interest rates. Second, we exclude the outlier countries Greece and Japan from the sample. Third, we correct an incorrectly implemented dummy variable in the data files of Poghosyan (2014). Finally, our data sample ends with data in 2013 rather than 2010.

The remainder of the paper is organized as follows. Section 2 reviews the existing literature. Section 3 describes the employed methodology and the data. Section 4 presents and discusses the empirical findings. Conclusions are in the final section.

2 Literature

The literature[2] consists of three main groups. The first group of literature considers the so-called equilibrium interest rate that corresponds to an equilibrium in some theoretical market. This rate anchors the empirically observed interest rates. The literature in this group explains the dynamics in the interest rate without focusing on a specific determinant. In contrast, the second group focuses on specific determinants of the interest rates. This literature tends to have an empirical focus. The third group

[1] The public sector purchase programme of the ECB buys bonds in the secondary market. The purchased bonds have a weighted remaining maturity below though close to 10 years.

[2] Other extensive literature reviews are in Gale and Orszag (2004), Poterba (2004), Haugh, Ollivaud and Turner (2009, Table 1), IMF (2009, Table 14), Broer (2010), Hassan, Salim, and Bloch (2011), Duffee (2012), and Maltritz (2012). The mixed results from Perotti (2002) in IMF (2009) should be replaced by the updated mixed results in Perotti (2004). While this paper uses the same sample as its predecessor, the spread in results has decreased.

studies the dynamics of term structure models. This literature includes latent factors as determinants of the term structure, which we do not consider here as it lacks a direct connection with economic fundamentals.[3]

2.1 Equilibrium interest rate

Wicksell (1898) defined the equilibrium rate as follows: "There is a certain rate of interest on loans which is neutral with respect to commodity prices, and tends neither to raise nor to lower them." Laubach and Williams (2015) operationalize this rate as the real short-term interest rate consistent with the economy operating at its full potential once transitory shocks to aggregate supply or demand have abated. An alternative definition of the equilibrium rate follows from the classical IS-LM framework. It states that the equilibrium rate is the interest rate that prevails when both the real economy (investments = savings) and the monetary economy (money demand = money supply) are in equilibrium. The equilibrium interest rate tends to abstract from temporary deviations, but also from more sophisticated concepts such as term preference, risk perception, expectations, etc. Still, movements in the equilibrium interest rate anchor movements in the empirically observed interest rates, for short-term rates as well as long-term rates.

In the VoxEU eBook on secular stagnation (Teulings and Baldwin, 2014), most contributions argue that equilibrium real rates of interest will remain low for the next decades. Examples include Chapter 1 by Summers, 4 by Krugman, 8 by Blanchard, Furceri and Pescatori, 9 by Caballero en Farhi, and 10 by Eggertsson and Mehrotra. In a related paper, Summers (2014) lists six explanations for the low real interest rates. We regard some explanations as permanent (P), some may build up further (P*), some are temporary (T) and some are uncertain or policy-dependent (P/T).

(i) *reductions in demand for debt-financed investments (P)*
   a. Establishing a new firm requires less investments than before, particularly because new firms tend to be tech-firms (P)
   b. Enhanced supervision on financial intermediation (P)
   c. The build-off of excessive leverage in the financial industry (T)
   d. Less public investments due to more stringent fiscal policy rules (P/T)

(ii) *a declining rate of population growth (P)*
   Relatedly, the growth rate of labor force has decreased. This is reinforced when considering the quality-adjusted labor force (P or prolonged T).

(iii) *changes in the distribution of income both between those with more wealth and those with less, and between labor income and capital income. The latter change in distribution is reinforced by the increase in corporate-retained*

[3] Extensive overviews on term structure models are in Piazzesi (2010) and Gürkaynak and Wright (2012). The first paper reviews term structure models from a finance perspective. The second one focuses on the interaction between macroeconomics and monetary policy.

earnings (P).*
These developments have raised the propensity to save on a macro scale (P*).

(iv) *a substantial decrease in the relative price of capital goods (P*)*
As a consequence, investment goods require less borrowing and spending, thereby reducing the propensity for investment (P*). This is related to (*i*).

(v) *substantial global moves to accumulate safe assets (T)*
The resulting higher price of safe assets reduced the corresponding yields, in nominal as well as in real terms (T).

(vi) *constant after-tax, rather than pre-tax, real interest rates (P/T)*
Keeping fixed both the marginal tax rate τ and the after-tax real rate $r_{\text{after}} = (1 - \tau)\, i - \pi$ implies that disinflation magnifies the decrease in the nominal interest rate and hence the (pre-tax) real rate $r = i - \pi$. (P/T)

A quantitative decomposition of most of the effects can be found in Rachel and Smith (2015). In total, the estimated effects explain 400 basis points (bp) of the 450bp drop in real rates since the 1980s. Around 100bp of this drop follows from the deterioration in the outlook for trend growth, another 300bp is due to a change in preferences. The decomposition and outlook is as follows (numbers refer to the listing above from Summers (2014)):

(*i*)	Lower public investment	20bp, policy-dependent
(*ii*)	Demographics	90bp, stable outlook, then reverse slowly
(*iii*)	Inequality	45bp, may build up further
(*iv*)	Lower price of capital goods	50bp, may build up further, but more slowly
(*v*)	Emerging markets' savings glut	25bp, likely to revert slowly
	Higher risk premiums	70bp, likely to remain stable
	Unexplained	50bp

Various determinants may explain the unexplained part. For instance, Rachel and Smith (2015) do not evaluate the effect of (*a*) a lower demand for *private* investments due to the decline in capital intensity of production, (*b*) the tax-effect (*vi*) from Summers (2014), and, more temporary, (*c*) the effect of deleveraging in (*i*) from Summers (2014). In any case, this cannot convincingly refute the medium and long-run estimate of 1% for the real rate by Rachel and Smith (2015).

The quantitative results are characterized by wide bands of uncertainty. This makes real rates hard to predict in the long-run. For instance, the 17th CEPR-ICMB Geneva Report on the World Economy (Bean, Broda, Ito and Kroszner, 2015) consider shifts in savings, associated especially with demographics as well as Chinese financial integration, as the dominant factor for the decline in interest rates, particularly in the decade or so before the financial crisis. After the crisis, a decline in the propensity to invest and shifts in asset supply and demand are likely to have played some role too. Bean et al. (2015) argue that real interest rates will return to more normal levels in

the long-run, but in the meantime deflationary traps are more likely, as are financial boom-bust cycles. The latter is in line with Rachel and Smith (2015).

The results in Hamilton, Harris, Hatzius and West (2015) indicate a quick recovery for the U.S. real interest rate to levels as seen in the past decades. The uncertainty around the equilibrium rate is large, and its relationship with GDP trend growth is much more tenuous than widely believed. While their data sample starts already in the 19th century, they do not control for factors that are significant in previous studies such as demographics and inequality in the distribution of income.

While long-run predictions vary, the consensus is that interest rates will stay low in the medium-run. This medium-run period is not without any danger for the long-run. For instance, BIS (2015) argues that the short-run benefit of a low interest rate regime persistently biases monetary policy towards a low interest rate regime. In the long-run, this results in asset price bubbles, macro-economic instability and chronic weakness, in line with Bean et al. (2015). In the words of BIS (2015), short-term gain risks being bought at the cost of long-term pain.

2.2 Specific determinants

In this section, we discuss literature assessing the effects of specific determinants on interest rates. We identify the following three main determinants from section 2.1: (*i*) demographics, (*ii*) demand and supply in the sovereign bond market, (*iii*) and income inequality. The empirical papers differ with respect to (*i*) nominal yields or real yields,[4] (*ii*) spreads or levels, (*iii*) current rates or forward rates, and (*iv*) a specific maturity or the whole term structure.

Demographics

Decisions on investment and savings are age dependent. Young individuals tend to borrow for housing investments, while individuals getting close to the pension age prefer to accumulate wealth anticipating a decline in income and higher expenditures for health care and leisure.

An extensive literature review on ageing is in Poterba (2004) who concludes that over the last 70 years the correlation between asset returns on stocks, bonds, or bills, and the age structure of the U.S. population is weak. He notes that a problem with the empirical data is the relatively short time span for the slowly varying ageing effect, and the difficulty to control for other factors. As a consequence, policy makers should rely on theoretical models to assess the effects of ageing.

[4] Dutch pension funds discount their liabilities with the euro swap rate. Particularly during crisis periods, swap rates might differ from sovereign bond yields (see e.g. ECB, 2014). Nonetheless, the low level of sovereign bond yields is related to the low level of swap rates.

The seminal book of Auerbach and Kotlikoff (1987, p.169) contains theoretical models where the interest rate declines from about 10% to 7% in response to a baby boom with a low fertility rate. Geanakoplos, Magill, and Quinzii (2004) develop a theoretical model where agents have perfect foresight. The population composition alternates from favorable (large working age size) to unfavorable (small working age size). Under several robustness checks they find an alternation of the real interest rate of several percentage points between the two different states.

Unfortunately, the implications of the theoretical models are not easily translated to the real world economy. Besides, some theoretical results rely heavily on seemingly small features. We give two examples. Firstly, the simulation in Krueger and Ludwig (2007) indicates a decline in the return to capital of 86bp between 2005 and 2080.[5] İmrohoroğlu (2007) remarks that the model of Krueger and Ludwig (2007) lacks the effect of total factor productivity. In a more recent model, Ludwig, Schelkle and Vogel (2012) include the accumulation of human capital and find that the decline in returns is halved. Secondly, Fehr, Jokisch and Kotlikoff (2008) find a huge increase in the risk free rate of 390 basis points in 2100 by imposing a strong home bias in investment flows.

A more recent literature survey on the effects of population age structure on savings and asset prices is in Hassan, Salim and Bloch (2011). In line with the discussion above, they conclude that both the empirical and the theoretical literature are inconclusive on the effect of age structure on the performance of financial markets. Some papers find no evidence of such an effect or mixed results, whilst other papers do find a significant effect. Hence, Poterba's (2004) assessment of empirical studies on the effects of ageing is extended to their theoretical counterparts. Lee (2014) states that existing simulation studies find a downward effect of ageing on rates of return, between 0.3% and 1%. Unfortunately, references to specific literature and simulation horizons are missing in this study.

Empirical evidence of an ageing effect on interest rates is provided in Haugh, Ollivaud and Turner (2009), Brunetti and Torricelli (2010), Ichiue and Shimizu (2015) and Šević and Brawn (2015). Noteworthy, Brunetti and Torricelli (2010) and Šević and Brawn (2015) do not control for the effects of debt and deficits. In addition, some of this literature could be driven by spurious regressions on non-stationary variables. Ichiue and Shimizu (2015) control for such effects by using time dummies. Their model suggests that a one percent increase in the working age population ratio growth rate (6–10 years ahead) increases the (annualized) 5-to-10-year forward real interest rate by 0.5%. It should be noted that time dummies may conceal omitted variables.

[5] A slightly larger decrease is in the follow-up paper of Ludwig, Krüger and Börsch-Supan (2009).

Sovereign bond market

A lower creditworthiness of a country makes future payments on debt more uncertain. As such, a higher debt rate or deficit of a country should be associated with higher bond yields for such a country.

Gale and Orzag (2004), Baldacci and Kumar (2010) and Greenlaw, Hamilton, Hooper, and Mishkin (2013) provide surveys on the effect of debt and deficits on sovereign interest rates. State-of-the-art data series and econometric techniques are in Laubach (2009) and Poghosyan (2014), respectively. The consensus in this literature is an interest rate sensitivity of 2-5bp on debt/GDP, and 15-60bp on deficit/GDP. Ichiue and Shimizu (2015) find that domestic borrowing (0.8bp on debt/GDP) is significantly less sensitive to the debt-to-GDP ratio than foreign borrowing (2.5bp). It is doubtful whether the estimates in this paper also apply to members of a monetary union.

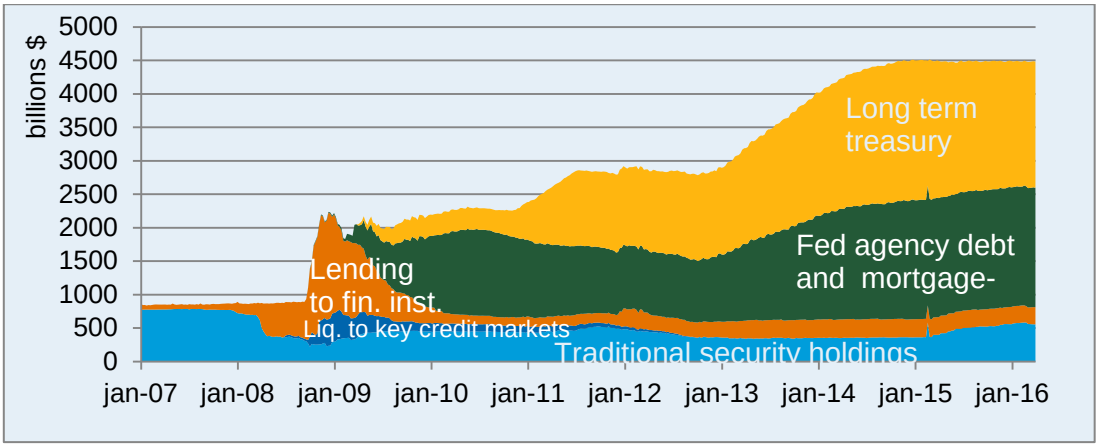
Apart from credit risk, demand and supply of a sovereign bond determine its price and thus its yield. Warnock and Warnock (2009) estimate that the 10-year Treasury yield would be 80 basis points higher without the substantial foreign inflows into the U.S. government bond market. They control for reductions in long-term inflation expectations, the volatility of long-term rates and various other factors.

The preferred habitat hypothesis states that different bond investors prefer one maturity length over another and are only willing to buy bonds outside of their maturity preference if a risk premium for the maturity range is present. Some papers investigate this hypothesis to explain irregularities in the term structure. Recent papers focusing on the bond supply of specific maturities include Krishnamurthy and Vissing-Jorgensen (2012) and Greenwood and Vayanos (2014). Both papers find that a larger supply of government debt decreases bond prices and thereby raises bond yields.

In response to the credit crisis, the Fed lowered interest rates by implementing quantitative easing (QE). In three different programs, the Fed bought assets worth around $3500 billion in the market. Figure 2.1 decomposes the new purchases on the Fed's balance sheet.

Several papers assess the Fed's QE program. Consistent with the preferred habitat hypothesis, D'Amico and King (2013) find that the effect of the Fed's 2009 program depends on the maturity length. Gagnon, Raskin, Remache and Sack (2011) find that Fed's asset purchases led to economically meaningful and long-lasting reductions in longer-term interest rates. The reductions in interest rates primarily reflect lower risk premiums, including term premiums, rather than lower expectations of future short-term interest rates.

Figure 2.1 Credit easing on Fed's balance sheet



Source: https://clevelandfed.org/en/our-research/indicators-and-data/credit-easing.aspx

Jarrow and Li (2014) reach an opposite conclusion by considering the Fed's 2008–11 QE program. Short- to medium- term forward rates were reduced (< 12 years), but the QE program had little if any impact on long-term forward rates. Nonetheless, QE also affected long-term bond yields since bond yields are averages of forward rates over a bond's maturity including the lower forward rates of the shortest maturities. Notably, no macro factor other than QE is included in their model. The literature review in Jarow and Li suggests that the QE operations until 2011 lowered interest rates by 50 to 100bp.

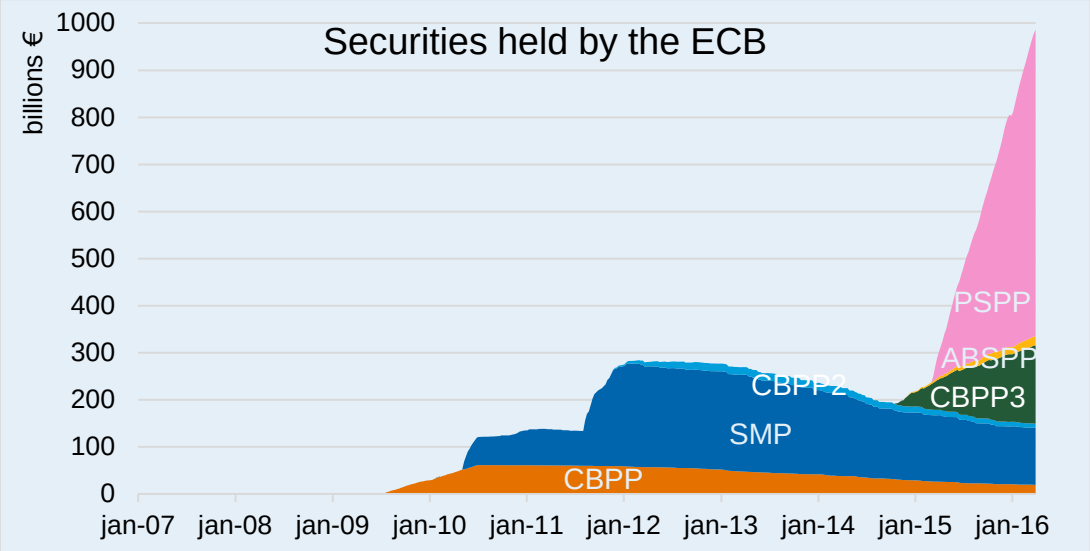
Table 2.1 Asset purchase programmes of the ECB

	Start	End	€ bln. as of 20 May 2016	Notes
SMP	10 May 2010	6 Sept 2012	111.0	€214 bln at top in April 2012
CBPP1	2 July 2009	30 June 2010	19.0	€61 bln at top in July/Aug 2010
CBPP2	Nov 2011	31 Oct 2012	8.4	€16.4 bln at top in Nov/Dec 2012
CBPP3	20 Oct 2014	end of Mar 2017*	176.2	
ABSPP	21 Nov 2014	end of Mar 2017*	19.1	€60 bln per mth, €80 bln since April 2016
PSPP	9 March 2015	end of Mar 2017*	780.1	

* Intended to be carried out until the end of March 2017 and in any case until the Governing Council sees a sustained adjustment in the path of inflation that is consistent with its aim of achieving inflation rates below, but close to, 2% over the medium term.
ABSPP = Asset-backed securities purchase programme, CBPP = Covered Bond Purchase Programme, SMP = Securities Markets Programme.
Source: https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html

Table 2.1 and Figure 2.2 summarize the asset purchase programs (APP) of the ECB so far. Additional nonstandard measures such as refinancing through the open market operations Main Refinancing Operations (MRO) and (targeted) Long Term Refinancing Operations (LTRO, LTRO II, TLTRO, TLTRO II) are not included in the table.

Figure 2.2 Securities held by the ECB



Notes: Holdings for monetary policy purposes.
Source: https://www.ecb.europa.eu/stats/monetary/res/html/index.en.html

A growing literature considers the effects of these asset purchase programs. The asset purchases under QE have led to a higher demand for bonds, limited re-usability of high quality collateral and reduced market liquidity. Valiante (2015) argues that the fragmentation of the sovereign bond markets in the euro area makes these markets inherently less liquid compared to the US sovereign bond market. This amplifies the adverse effects of QE on liquidity. This argument is still premature in light of the lower amount currently devoted to QE by the ECB compared to the Fed.

The effect of the SMP program is studied for Greece, Ireland, Italy, Portugal and Spain in Eser and Schwaab (2016). They report large announcement effects and an impact of 3 basis points at the five year maturity for each purchase of 1/1000 of the outstanding debt. The first three programs (SMP, CBPP1 and CBPP2) are examined in Gibson, Hall and Tavlas (2015) for the same five debt crisis countries. Their results indicate that the asset purchase programs in 2009–2012 reduced the sovereign bond spreads versus Germany and raised covered bond prices. The quantitative effects of the programs are modest in magnitude though significant. Indeed, our table reports that the total amount of assets on the balance sheet of ECB is currently much smaller than the $3500 billion of assets bought by the Fed during QE. Nonetheless, an ECB Working paper by Altavilla, Carboni and Motto (2015) find that APP has a sizeable impact on asset prices. ECB (2015) estimate the announcement effects of TLTRO and APP on 10-year sovereign bond yields at -0.23% and -0.47%, respectively.

European debt crisis

A related strand of literature considers sovereign yield spreads between Germany and other euro area countries. Since the euro area is a monetary union, the yield spreads indicate differences in credit risk due to differences in macro variables such

as fiscal variables. This literature has developed a consensus that the European debt crisis made investors more sensitive to fiscal balances. The specific determinants differ by country and over time.

The sharp spikes in government bond yield spreads during the debt crisis cannot purely be attributed to changes in macroeconomic fundamentals. The general pricing of risk has changed over time as well. Thus, the relationship between variables indicating default and liquidity risk and government bond yield spreads may be time-varying. Bernoth and Erdogan (2012) aim to capture this time-variation by estimating time varying coefficients using kernel regressions. They find that the strong increase in sovereign yield spreads during the euro crisis can be attributed to both a deterioration of the fiscal position of the country concerned, and an increase in general investors' risk aversion.

The latter effect is the focus of analysis by De Grauwe and Ji (2013) who consider the debt crisis as a bad equilibrium. By allowing for one structural break in a fixed effects model, they find evidence that a significant part of the surge in the spreads of the peripheral euro area countries was disconnected from underlying increases in fiscal variables. Investors became increasingly worried about debt levels in the euro area, and reacted by raising the spreads. As a consequence, the crisis was associated with negative self-fulfilling market sentiments. Such behavior is not observed in countries outside the euro area.

Rather than time variation in risk perception, Favero (2013) uses time-varying differences in fiscal fundamentals between countries. More specifically, a country-specific factor based on cross-country differences captures currency devaluation risk, i.e. breakup risk of the euro area. The dynamics of this factor are more similar for two countries if the debt rate and fiscal balance are more similar for both countries. The factor improves the model on out-of-sample forecasts for the period 2010–2012. Still, the model cannot predict the large spreads observed during the debt crisis.

Cross-country variation in determinants may also play a role. Particularly, sovereign yields of countries in Southern Europe may respond in a different way compared to countries in Northern Europe. By adopting a general-to-specific selection procedure for regressors, Afonso, Arghyrou, Bagdatoglou and Kontonikas (2015) find a significant heterogeneity in determinants of spreads across groups of countries both in terms of the risk factors determining spreads over time and in terms of the magnitude of their impact on spreads. The set of financial and macro spreads' determinants in the euro area is rather unstable, but generally became richer. The significance of the determinants increased as the crisis evolved.

The vast majority of papers consider spreads vis-à-vis Germany. An exception is Dewachter, Iania, Lyrio, and de Sola Perea (2015) who consider the sovereign bond yields for five euro area countries vis-à-vis the Overnight Interest Swap rate (OIS).

They find that economic fundamentals are the dominant drivers of credit risk. Still, other shocks such as liquidity and political uncertainty also played a role in the sovereign debt crisis.

Income inequality

The literature finds a mixed effect of income inequality on interest rates. The empirical findings in Alesina and Perotti (1995) suggest that more income inequality leads to more social-political instability which in turn leads to less investment. However, their inequality measure is static and based on 1960 data. This is meant to tackle the endogeneity problem, but has a high price given the dynamics in income inequality throughout the sample that ends in 1985. In a later study, Barro (2000) finds that the investment ratio does not depend significantly on inequality, as measured by the Gini coefficient.

In our empirical setting, we do not attempt to quantify the effect of inequality on interest rates for three reasons. First, there is an inherent endogeneity problem. If lower interest rates induce more investment, the possible increase in capital income is for capital owners who are mostly in the highest income percentiles. At the same time, a higher inequality in income (or wealth) leads to a higher propensity to save at a macro level and thus a lower interest rate. Hence, the causal relationship between income inequality and interest rate is unclear. Second, it is not clear-cut whether a lower demand for investment in some (small) open economy leads to lower sovereign yields for that specific country. Obviously, globalization trends exclude cross-country arbitrage on sovereign debt. Third, data on income and particularly on wealth has serious measurement issues. Ideally, data collection methods should be identical over time and across countries. Though interesting, tackling these three important aspects on inequality is a study on its own.

Other determinants

The considered studies control for the impact of several other variables. For instance, GDP growth has an estimated effect on the nominal interest rate of roughly 15bp to 35bp, the effect of the inflation rate ranges between 14bp and 65bp. Some studies test implicitly on the effect of the short-term interest rate on the long-term interest rate. An effect between 35bp and 75bp is reported. We are skeptical on including a short-term rate since other determinants may simultaneously affect short-term and long-term rates by shifting the whole term structure.

3 Methodology and data

Our empirical analysis of the determinants of the long-term interest rate elaborates on the analysis by Poghosyan (2014). As motivated in the introduction we use a cross-country panel with 10-year nominal government bond yields to analyse the

long-term interest rate dynamics. The cross-sectional setup of panel data enables us to obtain more efficient estimates than using single country data. In addition to the determinants analysed by Poghosyan (2014), we tested for other variables, for example alternative indicators for fiscal policy (government debt and budget balance) and demographic variables.

Most of the literature estimates a static regression or a VAR to determine the main determinants of the interest rate. An error correction model is used by only a few papers including Orr et al. (1995) and Poghosyan (2014). Our choice of the panel cointegration model is motivated by the non-stationarity of some variables (Appendix Table A.1) and the ability of the error correction model to distinguish between long-run and short-run determinants. We expect that similar variables determine the yields of developed countries, thus we consider a panel of 20 OECD countries.

Since some of our explanatory variables are not stationary we use a panel cointegration model:

$$\Delta y_{it} = \gamma_i (y_{it-1} - aX_{it-1}) + b_i \Delta W_{it} \quad (1)$$

Here the subscripts i and t refer to the country i and the year t respectively. y_{it} is the 10 year bond yield, X_{it} and W_{it} are explanatory variables, a contains the parameters that are constrained to be identical across countries, and γ_i and b_i contain parameters that are allowed to differ across countries.

The estimator for (1), the so-called pooled mean group (PMG) estimator, was introduced by Pesaran et al. (1999). By using the PMG estimator, the set of variables in the long-run regression (X_{it}) has the same impact (a) on the dependent variable (y) across countries. The error correction (adjustment) parameter γ_i and the set of variables determining the short-run deviations (ΔW_{it}) have a country-specific impact. This means that the long-run equation is identical for each country, while cross-country heterogeneity in the short-run is allowed.

In order to check the robustness of our results, we also estimate a simple static model for the long-run regression:

$$y_{it} = aX_{it} \quad (2)$$

Another concern about the estimation of equation (1) is that the dependent and at least some of the explanatory variables may suffer from cross-country dependence. That is, the yearly changes in the explanatory variables are not independent between countries. One way to eliminate this cross-country dependence is to estimate the regression for the deviations from the yearly means, i.e. for $y_{it} - \bar{y}_t$, $X_{it} - \bar{X}_t$ and $\Delta W_{it} - \Delta \bar{W}_{it}$:

$$\Delta(y_{it} - \bar{y}_t) = \gamma_i((y_{it-1} - \bar{y}_{t-1}) - a(X_{it-1} - \bar{X}_{t-1})) + b_i(\Delta W_{it} - \Delta \bar{W}_{it}) \qquad (3)$$

The annual change in yearly means eliminates potential cross-country dependence in annual changes. The disadvantage of the estimation of the regression (3) is that it leaves unexplained the common trends in the bond yields. More specifically, it is not helpful in explaining the downward trend in the interest rates during the last decades.

Explanatory variables included in the regression

In order to explain the government bond yield dynamics, we include variables determining saving-investment decisions and variables indicating investment risk. We include the growth rate of potential GDP as a determinant of the long-term interest rate, although we are not sure about the sign of its coefficient. On the one hand, potential GDP growth is an indicator for the expected returns on alternative investment opportunities. A higher potential growth rate reduces the demand for bonds and so bond prices. Thus potential growth can have a positive impact on the government bond yield. On the other hand, a high potential GDP growth rate can improve expectations about tax revenues and decrease the default risk on government bonds. Thus potential growth can have a negative effect on the government bond yield as well.

As our dependent variable is the nominal yield and not the real yield, we include an inflation rate (calculated using the GDP deflator) as an explanatory variable. In this way we can check whether there is a one-to-one relation between the bond yields and inflation. Following Wright (2011), we also test for the effect of the volatility in inflation rates (calculated as 12 months inflation rates standard deviation) on long-term interest rates, since current monetary policy tends to adopt an inflation target in setting monetary policy which reduces inflation uncertainty.

As another potential determinant affecting the government bond yield we include gross government debt as a share of GDP, because gross government debt is a measure of default risk. However, after the creation of the European Monetary Union (EMU), government bond yields converged across the EMU countries. Probably investors believed that joining the EMU reduced default risk regardless of the level of government debt. We account for this particular effect on risk perception on European sovereigns by including in our regressions government debt interacted with a dummy that is equal to one for members of the euro area.

The changing age structure of the population is another potentially important determinant for interest rates. In most high-income countries the share of the young working-age population is decreasing while the fraction of pensioners is increasing. We tried to include several demographic variables in our model to account for these trends. The most significant demographic variables turned out to be the share of the age group 20-39 in the total population and the share of the age group 40-64 in the

total population. The 20-39 share has a positive effect on the interest rate, as this age group has a relatively high consumption compared to saving. In addition, this group tends to borrow for mortgages and child rearing. The 40-64 share has a negative effect on the interest rate as middle-aged individuals start saving more due to a higher income, lower expenses on child rearing and housing, and more precautionary savings anticipating lower income after retirement. This increase in savings affects the interest rate negatively. Due to multicollinearity we cannot include both population variables in the regression. We include the 20-39 share, which turned out to be the most significant.

Data

For the estimations we use yearly data of 20 OECD countries: Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, South Korea, the Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. As the data before 1990 is scarce we use yearly data for the 1990-2013 period. Most data series are from the IMF World Economic Outlook 2015 April database.[6] Government 10-year bond yields are obtained from Datastream. Population age group shares are calculated using the 2015 Revision of World Population Prospects from the United Nations.[7]

4 Empirical results

First, we estimate equation (1) using the following explanatory variables: Gross government debt, potential growth, the 20-39 age population share, the inflation rate and the inflation standard deviation. Appendix Table A.1 contains unit root tests for the analysed variables. Nominal long-term yields, government debt, potential growth and the 20-39 age population share are likely to contain a unit root, at least for some countries. Column (I) in Table A.1 indicates that cointegration is present in the panel, at least for some countries. The estimation results of the regression (1) are given in column (I) of Table 4.1. In column (II) we keep the significant determinants after stepwise eliminating the insignificant ones. The 20-39 population share is the most significant determinant. The corresponding parameter is about 0.6 which indicates that a 1 percentage point (pp) increase in the 20-39 population share results in an increase of 0.6 pp in the long-term interest rates.

Both the 20-39 population share and potential growth exhibit a downward trend in the data sample. As a consequence, the impact of the 20-39 population share may be overestimated due to the positive correlation with potential growth.
After excluding the insignificant variables, the potential growth parameter is positive

[6] http://www.imf.org/external/pubs/ft/weo/2015/01/weodata/index.aspx.
[7] http://esa.un.org/unpd/wpp/DVD/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_Population/WPP2015_POP_F07_1_POPULATION_BY_AGE_BOTH_SEXES.XLS.

Table 4.1 Cointegration model, pooled-mean-group estimator

	(I)	(II)
	LONG-RUN EQUATION	
Government debt	-0.0100**	-0.0173***
	[-2.17]	[-3.15]
Government debt *dEU	0.0230***	0.0147**
	[4.58]	[2.51]
Potential growth	-0.142**	0.147**
	[-2.12]	[2.05]
Inflation	0.691***	0.863***
	[11.71]	[18.18]
Inflation standard deviation	1.221***	
	[3.82]	
Population 20-39 share[1]	0.598***	0.624***
	[23.46]	[26.39]
Constant	2.848***	3.307***
	[11.22]	[11.02]
	SHORT-RUN EQUATION	
Error correction coefficient	-0.368***	-0.273***
	[-4.63]	[-4.59]
Δ(Government debt)	0.00727	
	[0.30]	
Δ(Potential growth)	0.285	0.285*
	[1.60]	[1.78]
Δ(Government debt *dEU)	-0.0165	
	[-1.28]	
Δ(Inflation)	0.175***	0.213***
	[3.22]	[5.33]
Δ(Inflation standard deviation)	0.462*	
	[1.67]	
Δ(Population 20-39 share)	-0.720	
	[-1.29]	
N	426	426
Log-likelihood	-436.2	-506.1
Variance Δ(bond yield)	1.27	1.27
Variance fitted values for Δ(bond yield)	0.60	0.29
Variance residuals	0.69	0.98

Notes: The dependent variable is the 10-year nominal sovereign bond yield
.*t* statistics in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
[1] The 20-39 population share is the deviation from the estimation sample mean.

but rather small: 1 pp increase in the potential GDP growth rate increases the long-term interest rate by 0.1 pp. If we exclude the 20-39 age population share from the specification in Table 4.1 column (II), the potential growth parameter increases to 1.3 (not reported). This confirms that the 20-39 share parameter picks up a substantial part of the positive effect of potential growth on the yield due to high correlation.

The inflation parameter is significant and equal to 0.8. The coefficient is significantly different from 1. The impact of current inflation on ten year bond yields may be less than 1, due to mean reversion in inflation. Ideally we would like to include expected

inflation during the next 10 years as explantory variable, but that was not available. The inflation volatility is a significant determinant in the initial specification (column (I)). However, it becomes insignificant when we exclude other insignificant variables from the regression.

The government debt parameter has an unexpected negative sign. Since the financial crisis government bond yields dropped despite a surge in government debt levels. This contrasts with an effect of default risk as this would imply a positive sign. However, the government parameter is sensitive to the regression setup. The government debt parameter becomes positive when we estimate the static model (2).

The error correction parameter is -0.3, which implies that on average the adjustment towards the long-run equilibrium is quite slow with a half-life of 2.2 years. The significance of the error correction parameter in the PMG estimation in Table 4.1 indicates that the dependent and explanatory variables in the regression cointegrate. As a more formal test, we test for the presence of unit roots in the residuals of the long-run equation estimates in Table 4.1. The results are given in the two rightmost columns in Appendix Table A.1. We see that all unit roots tests reject the hypothesis about the unit root in the residuals (when only significant variables are left in the regression). The Hadri LM test considers the hypothesis of stationarity against the hypothesis that at least one of the panels is non-stationary. The results indicate that for some countries in our sample the cointegration relation may not hold. Nevertheless, the tests show that the cointegration holds for the majority of the countries in our sample.

To check whether the results from the dynamic model (1) are robust, Table 4.2 reports the estimation results of the static model (2). There might be cross-country dependence between variables, which means that the standard errors of the parameters could be underestimated. This motivates us to include the bootstrapped standard errors in column (II) in Table 4.2. In order to account for the autocorrelation in the residuals, we estimate a regression that allows for the autocorrelation in the residuals of order 1 in columns (III)-(IV) in Table 4.2.

According to the results of the static estimation, the 20-39 population share is still the most significant determinant for the long-term interest rates. The government debt parameter is positive in this static setting, although it is insignificant when we account for the autocorrelation in the residuals. The inflation parameter is substantially smaller than in the dynamic setting and is again significantly lower than one.

Appendix Table A.2 presents the results for the estimation of the dynamic regression for the deviations from the yearly means. This regression explains the cross-country differences in the long-term bond yields. Only a few variables remain significant. The results suggest that cross-country differences in the long-term interest rate can be

partly explained by the differences in potential growth and 20-39 population share. However, the 20-39 population share parameter decreases substantially to 0.1. Again, the gross government debt parameter has an unexpected negative sign.

Table 4.2 Static regression estimation

	(I)	(II)	(III)	(IV)
		Bootstrapped s.e.	with AR(1) residuals,	with AR(1) residuals
Country effects	fixed	fixed	fixed	random
Government debt	0.0396***	0.0396*	0.00913	0.00833
	[7.14]	[1.88]	[1.00]	[1.14]
Government debt *dEU	-0.0145***	-0.0145*	0.00595	-0.000488
	[-3.97]	[-1.81]	[1.26]	[-0.11]
Potential growth	0.0600	0.0600	0.100	0.0751
	[0.78]	[0.44]	[1.63]	[1.17]
Inflation	0.281***	0.281***	0.107***	0.166***
	[5.04]	[2.90]	[2.82]	[4.29]
Inflation s. d.	0.543**	0.543*	0.0745	0.112
	[2.08]	[1.80]	[0.45]	[0.63]
20-39 population share	0.557***	0.557***	0.339***	0.587***
	[11.77]	[4.43]	[2.98]	[7.07]
Constant	2.692***	2.692*	3.525***	4.943***
	[5.47]	[1.92]	[23.00]	[8.71]
N	437	437	417	437
R^2 (overall)	0.371	0.371	0.291	0.340

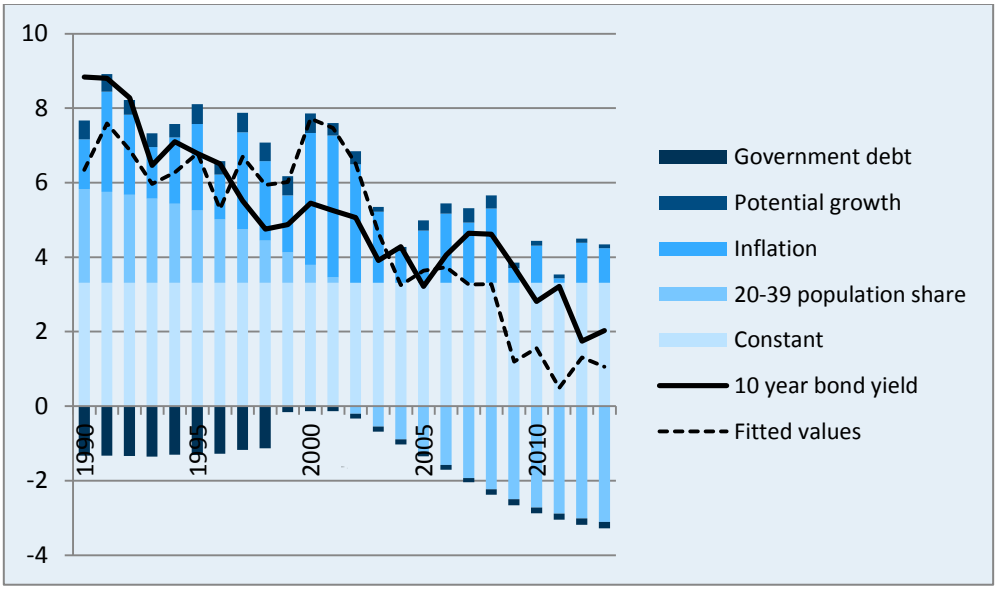
Notes: The dependent variable is the 10-year nominal sovereign bond yield.
t statistics in brackets; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Implications

We explain the decrease in the long-term interest rate for the Netherlands, using the specification in column (II) in Table 4.1. The factor decomposition for the Netherlands is depicted in Figure 4.1. The main determinants of the interest rate decrease for Dutch 10-year government bonds are the change in the population structure and the lower inflation.

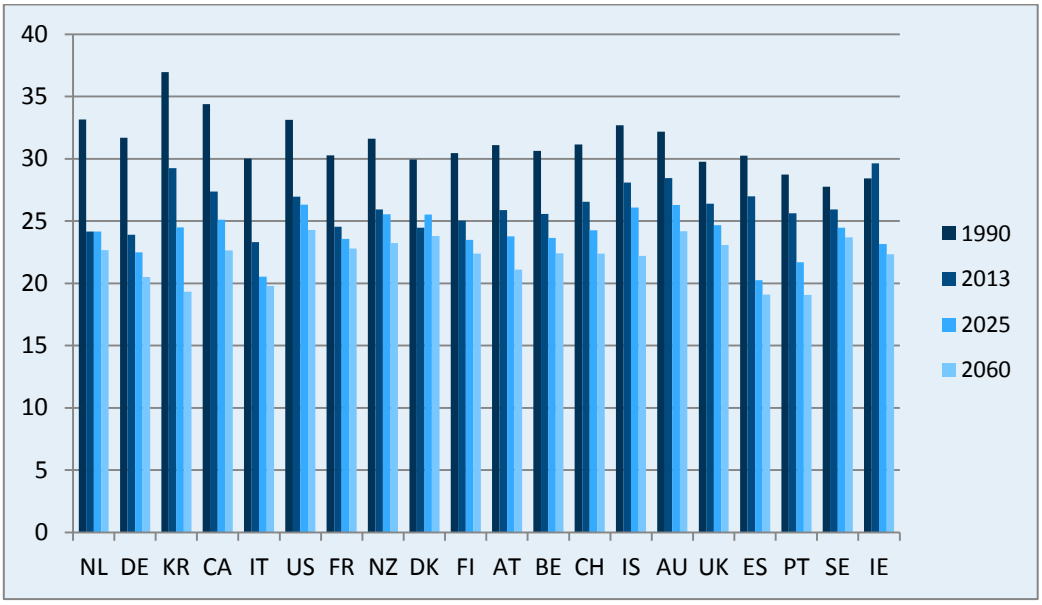
Figure 4.2 presents the change in 20-39 age population share in 1990-2013, as well as the United Nations' median scenario forecasts for the 20-39 population share in 2025 and 2060 for all the countries in our sample. The decrease in the 20-39 population share in 1990-2013 was the largest in the Netherlands. Consequently the negative effect arising from the decrease of this young working age population share was the largest for the Netherlands. The United Nations project a stabilization of the young age population share in the Netherlands in the next decade and only a slight decrease afterwards. This population share may drop further for other countries. Thus, if our estimates are correct and remain valid for the future, the impact of demography on the interest rate is long lasting.

Figure 4.1 10 year bond yield decomposition for the Netherlands, in %-points, based on estimates in Table 4.1 column (II)



Note: The population share is included as the deviation from the sample mean of the Netherlands, which gives a negative effect in the 2nd half of the sample.

Figure 4.2 20-39 actual share in total population across countries in 1990 and 2013, and forecasted share in



Note: The countries are in the decreasing order of the change in the 20-39 population share, NL- the Netherlands, DE- Germany, KR- South Korea, CA- Canada, IT- Italy, US- the US, FR- France, NZ- New Zealand, DK- Denmark, FI- Finland, AT- Austria, BE- Belgium, CH- Switzerland, IS- Iceland, AU- Australia, UK- the UK, ES- Spain, PT- Portugal, SE- Sweden, IE- Ireland.
Source: United Nations, Department of Economic and Social Affairs, Population Division (2015). World Population Prospects: The 2015 Revision. For 2025 and 2060 we take medium variant forecasts. http://esa.un.org/unpd/wpp/DVD/Files/1_Indicators%20(Standard)/EXCEL_FILES/1_Population/WPP2015_POP_F07_1_POPULATION_BY_AGE_BOTH_SEXES.XLS.

5 Concluding remarks

The nominal long-term interest rate decreased in the past decades due to the decrease in (expected) inflation and in potential growth, and due to changes in the age structure of the population. This conclusion is based on our survey of the literature and our empirical findings for the long-term interest rate in high-income countries since 1990. The instantaneous relation between nominal interest rates and macroeconomic fundamentals is relatively weak, as demonstrated by the low explanatory power of our regression analysis.

Inflation expectations are low, due to a low inflation rate in the past three decades as a result of inflation targeting monetary policies, and due to a low capacity utilization rate and a high unemployment rate. Wage increases are moderate, as long as unemployment is high. Producers are reluctant to increase prices if capacity utilization is low. The cyclical downturn reduced the demand for raw materials and resulted in low prices. Potential growth reduced due to a diminishing population growth in particular of young workers as well as a diminishing increase in the education level of the population.

Capital supply has increased due to higher pension savings, partly because of the increasing share of elderly workers and the increase in life expectancy. High savings in emerging countries and loose monetary policy by central banks also played a role in the supply of capital. The demand to invest these higher savings in safe government bonds has increased due to regulation for financial institutions and through quantitative easing by central banks. This higher demand for bonds has an upward impact on their price, so a downward impact on the interest rate. The demand for capital was reduced by the cyclical downturn after the financial crisis. There was little appetite for new investment, due to low capacity utilization.

The consensus is that the interest rate will somewhat recover, but not return to historical levels.[8] This is in line with forward rates. The recovery is due to short-term determinants. If economic recovery continues, a lower unemployment, a higher utilisation of production capacity and a higher demand for raw materials can cause more inflationary pressure. A higher inflation rate and less loose monetary policy can cause an increase of nominal interest rates. Structural reforms and stable debt positions can have a positive impact on potential growth. The recovery is limited due to long-term determinants. The contribution of labour supply on economic growth remains limited due to changes in the age structure of the population. Growth of pension savings may diminish, but pension wealth remains probably at a high level.

[8] See e.g. Summers (2014), BIS (2015) and Blanchard (2016).

Appendix

Table A.1 Unit root tests for the variables and residuals (p-values)

	Long-term interest rate	Government debt	Potential growth	Inflation	Inflation s.d.	Population 20-39 share	Residuals (I)	Residuals (II)
Im-Pesaran-Shin test	H_0: All panels contain unit roots				H_1: At least one stationary panel			
No lag in the ADF regression	0.46	1.00	0.60	0.00	0.00	1.00	0.00	0.00
1-3 lags (AIC criteria) in the ADF regression	0.38	0.08	0.16	0.00	0.00	0.00	0.01	0.00
Fisher-type test of Choi (2001)	H_0: All panels contain unit roots				H_1: At least one stationary panel			
No lag in the ADF regression	0.51	1.00	0.54	0.00	0.00	0.95	0.00	0.00
1 lag in the ADF regression	0.67	0.17	0.34	0.00	0.00	0.00	0.14	0.02
Levin-Lin-Chu test	H_0: All panels contain unit roots				H_1: At least one stationary panel			
No lag in the ADF regression	0.00	0.89	0.00	0.00	0.00	1.00	0.00	0.00
1-3 lags (AIC criteria) in the ADF regression	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00
Breitung test	H_0: All panels contain unit roots				H_1: At least one stationary panel			
No prewhitening	0.00	0.77	0.00	0.00	0.00	1.00	0.00	0.00
Prewhitening with 1 lag	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00
Hadri LM test	H_0: All panels are stationary				H_1: Some panels contain unit roots			
Robust for serial correlation and heteroskedasticity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Residuals (I) and (II) refer to the residuals from the long-run equations in Table 4.1 columns (I) and (II) respectively. H_0: Null hypothesis, H_1: Alternative hypothesis.
The Breitung test and the Hadri LM test require a balanced panel. For these tests, the panel was reduced to 18 countries (from 20) and 19 (from 24) years. This is based on minimizing the number of excluded observations.

Table A.2 Estimation for the deviations from yearly means

	(I)	(II)
	LONG-RUN EQUATION	
Government debt	0.00115	-0.0146***
	[0.71]	[-3.43]
Government debt *dEU	-0.000362	
	[-0.22]	
Potential growth	0.151*	0.241**
	[1.96]	[2.51]
Inflation	-0.0244	
	[-0.52]	
Inflation s. d.	0.755***	
	[3.01]	
20-39 population share	0.0439*	0.101**
	[1.69]	[2.51]
Constant	-0.294***	-0.359***
	[-5.07]	[-4.51]
	SHORT-RUN EQUATION	
Error correction parameter	-0.399***	-0.273***
	[-5.30]	[-5.82]
Δ Government debt	0.00951	
	[0.47]	
Δ Government debt *dEU	0.00425	
	[0.13]	
Δ Potential growth	-0.150	
	[-0.76]	
Δ Inflation	0.0623	
	[1.09]	
Δ Inflation s. d.	-0.0827	
	[-0.31]	
Δ 20-39 population share	-0.406**	-0.478***
	[-2.18]	[-2.78]
N	426	435
Log-likelihood	-202.2	-307.9

Notes: The dependent variable is the 10-year nominal sovereign bond yield in deviation from yearly means.
t statistics in brackets.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Literature

Afonso, António, Michael G. Arghyrou, George Bagdatoglou and Alexandros Kontonikas, 2015, On the time-varying relationship between EMU sovereign spreads and their determinants, *Economic Modelling,* vol. 44: 363-371. link

Alesina, Alberto, and Roberto Perotti, 1996, Income distribution, political instability, and investment, *European Economic Review,* vol. 40(6): 1203-1228. link

Altavilla, Carlo, Giacomo Carboni, and Roberto Motto, 2015, Asset purchase programmes and financial markets: lessons from the euro area, ECB Working Paper 1864. link

D'Amico, Stefania and Thomas B. King, 2013, Flow and stock effects of large-scale treasury purchases: Evidence on the importance of local supply, *Journal of Financial Economics*, vol. 108(2): 425-448. link

Auerbach, Alan J. and Laurence J. Kotlikoff, 1987, *Dynamic fiscal policy*, Cambridge University Press. link

Baldacci, Emanuele and Manmohan Kumar, 2010, Fiscal deficits, public debt, and sovereign bond yields, IMF Working Paper 10/184. link

Barro, Robert J., 2000, Inequality and Growth in a Panel of Countries, *Journal of Economic Growth* , vol. 5(1): 5-32. link

Bean, Charles, Christian Broda, Takatoshi Ito, and Randall Kroszner, 2015, Low for long? Causes and consequences of persistently low interest rates, International Center for Money and Banking, Geneva Report 17. link

Bernoth, Kerstin, and Burcu Erdogan, 2012, Sovereign bond yield spreads: A time-varying coefficient approach, *Journal of International Money and Finance*, vol. 31(3): 639-656. link

Blanchard, Olivier, 2016, Slow Growth Is a Fact of Life in the Post-Crisis World, *Financial Times*, 13 April 2016. link

BIS, 2015, *85th Annual Report*, Bank of International Settlements. link

Broer, Peter, 2010, Macroeconomic risks and pension returns, CPB Memorandum 241. link

Brunetti, Marianna and Costanza Torricelli, 2010, Demographics and asset returns: does the dynamics of population ageing matter?, *Annals of Finance*, vol. 6(2): 193-219. link

Choi, I., 2001, Unit root tests for panel data, *Journal of International Money and Finance*, vol. 20: 249–272. link

Dewachter, Hans, Leonardo Iania, Marco Lyrio and Maite de Sola Perea, 2015, A macro-financial analysis of the euro area sovereign bond market, *Journal of Banking & Finance,* vol. 50: 308-325. link

Duffee, Gregory R., 2013, Bond pricing and the macroeconomy,in: George M. Constantinides, Milton Harris and Rene M. Stulz (eds), *Handbook of the Economics of Finance* 2 Part B, Elsevier: 907-967. link

ECB, 2014, Euro area risk-free interest rates: Measurement Issues, recent developments and relevance to monetary policy, *ECB Monthly Bulletin*, July 2014. link

ECB, 2015, The transmission of the ECB's recent non-standard monetary policy measures, *Economic Bulletin*, vol. 7. link

Eser, Fabian and Bernd Schwaab, 2016, Evaluating the impact of unconventional monetary policy measures: Empirical evidence from the ECB′ s Securities Markets Programme, *Journal of Financial Economics*, vol. 119(1): 147-167. link

Favero, Carlo A., 2013, Modelling and forecasting government bond spreads in the euro area: a GVAR model, *Journal of Econometrics*, vol. 177(2): 343-356. link

Fehr, Hans, Sabine Jokisch, and Laurence J. Kotlikoff, 2008, Fertility, mortality and the developed world's demographic transition, *Journal of Policy Modeling*, vol. 30(3): 455-473. link

Gagnon, Joseph, Matthew Raskin, Julie Remache and Brian Sack, 2011, The financial market effects of the Federal Reserve's large-scale asset purchases, *International Journal of Central Banking*, vol. 7(1): 3-43. link

Gale, William G., and Peter R. Orszag, 2004, Budget deficits, national saving, and interest rates, Brookings Papers on Economic Activit, 2004(2): 101-210. link

Geanakoplos, John, Michael Magill, and Martine Quinzii, Demography and the long-run predictability of the stock market, *Brookings Papers on Economic Activity*, 2004(1): 241-325. link

Gibson, Heather D., Stephen G. Hall, George S. Tavlas, 2015, The effectiveness of the ECB's asset purchase programs of 2009 to 2012, *Journal of Macroeconomics.* link

Goodhart, Charles A.E. and Philipp Erfurth, 2014, Demography and economics: Look past the past, VoxEU.org, Nov 4. link

Grauwe, Paul de, and Yuemei Ji, 2013, Self-fulfilling crises in the Eurozone: An empirical test, *Journal of International Money and Finance,* vol. 34: 15-36. link

Greenlaw, David, James D. Hamilton, Peter Hooper and Frederic S. Mishkin, 2014, Crunch time: Fiscal crises and the role of monetary policy, NBER Working Paper 19297. link

Greenwood, Robin, and Dimitri Vayanos, 2014, Bond supply and excess bond returns, *Review of Financial Studies*, vol. 27(3): 663-713. link

Gürkaynak, Refet S., and Jonathan H. Wright, Macroeconomics and the term structure, *Journal of Economic Literature*, vol. 50(2): 331-367. link

Hamilton, James. D., Ethan S. Harris, Jan Hatzius and Kenneth D. West, 2015, The equilibrium real funds rate: Past, present and future, NBER Working Paper 21476. link

Hassan, A.F.M., Ruhul Salim and Harry Bloch, 2011, Population age structure, saving, capital flows and the real exchange rate: A survey of the literature, *Journal of Economic Surveys*, vol. 25(4): 708-736. link

Haugh, David, Patrice Ollivaud and David Turner, 2009, What Drives Sovereign Risk Premiums?, OECD Economics Department Working Papers 718. link

Ichiue, Hibiki and Yuhei Shimizu, 2015, Determinants of long-term yields: A panel data analysis of major countries, *Japan and the World Economy*, vol. 34: 44-55. link

Im, K.S., M.H. Pesaran and Y. Shin, 2003, Testing for unit roots in heterogeneous panels, *Journal of Econometrics*, vol. 115: 53–74. link

IMF, 2009, The State of Public Finances: Outlook and Medium-Term Policies After the 2008 Crisis, International Monetary Fund Companion Paper. link

İmrohoroğlu, Ayşe, 2007, Consequences of demographic change for rates of returns to capital, and the distribution of wealth and welfare: A comment, *Journal of Monetary Economics*. vol.54(1): 88-91. link

Jarrow, Robert and Hao Li, 2014, The impact of quantitative easing on the US term structure of interest rates, *Review of Derivatives Research*, vol. 17(3): 287-321. link

Krishnamurthy, Arvind and Annette Vissing-Jorgensen, 2012, The aggregate demand for treasury debt, *Journal of Political Economy*, vol. 120(2): 233-267. link

Krueger, Dirk and Alexander Ludwig, 2007, On the consequences of demographic change for rates of returns to capital, and the distribution of wealth and welfare, *Journal of Monetary Economics*, vol. 54(1): 49-87. link

Laubach, Thomas, 2009, New evidence on the interest rate effects of budget deficits and debt, *Journal of the European Economic Association*, vol. 7(4): 858-885. link

Laubach, Thomas, and John C. Williams, 2015, Measuring the natural rate of interest redux, Federal Reserve Bank of San Francisco Working Paper Series 16. link

Lee, Ronald D., 2014, Macroeconomic consequences of population aging in the United States: Overview of a national Academy Report, *American Economic Review*, vol. 104(5): 234-239. link

Ludwig, Alexander, Dirk Krüger, and Axel Börsch-Supan, 2009, Demographic change, relative factor prices, international capital flows, and their differential effects on the welfare of generations, *Social Security Policy in a Changing Environment*, University of Chicago Press, 385-414. link

Ludwig, Alexander, Thomas Schelkle, and Edgar Vogel, 2012, Demographic change, human capital and welfare, *Review of Economic Dynamics*, vol. 15(1) : 94-107. link

Maltritz, Dominik, 2012, Determinants of sovereign yield spreads in the Eurozone: A Bayesian approach, *Journal of International Money and Finance* 31.3: 657-672. link

Perotti, Roberto, 2005, Estimating the effects of fiscal policy in OECD countries, Università Bocconi Working Paper 276. link

Pesaran, M. Hashem, Yongcheoi Shin, and Ron P. Smith, 1999, Pooled mean group estimation of dynamic heterogeneous panels, *Journal of the American Statistical Association*, vol. 94(446): 621-634. link

Piazzesi, Monika, 2010, Affine term structure models, in: Yacine Ait-Sahalia and Lars Peter Hansen (eds), *Handbook of Financial Econometrics* 1: *Tools and Techniques,* Elsevier: 691-766. link

Poghosyan, Tigran, 2014, Long-run and short-run determinants of sovereign bond yields in advanced economies, *Economic Systems*, vol. 38(1): 100-114. link

Poterba, James, 2004, The impact of population aging on financial markets. NBER Working Paper 10851. link

Rachel, Lukasz and Thomas D. Smith, 2015, Secular drivers of the global real interest rate, Bank of England Working Paper 571. link

Reinhart, Carmen M. and M. Belen Sbrancia, 2015, The liquidation of government debt, *Economic Policy*, vol. 30(82): 291-333. link

Šević, Aleksandar and Derek Brawn, 2015, Do demographic changes matter? A cross-country perspective, *Journal of Multinational Financial Management,* vol. 30: 36-61. link

Summers, Lawrence H, 2014, U.S. economic prospects: Secular stagnation, hysteresis, and the zero lower bound, *Business Economics*, vol 49(2): 65-73.

Teulings, Coen and Richard Baldwin, 2014, Secular stagnation: Facts, causes and cures, London: Centre for Economic Policy Research-CEPR. link

Valiante, Diego, 2015, The 'Visible Hand' of the ECB's Quantitative Easing, CEPS Working Document 407. link

Villar Burke, Javier, 2016, The interventions of the European Central Bank throughout the crisis, SSRN Working Paper 2555921. link

Warnock, Francis E. and Veronica Cacdac Warnock, 2009, International capital flows and US interest rates, *Journal of International Money and Finance*, vol. 28(6): 903-919. link

Wicksell, Knut, 1898, *Interest and prices*, (translated version 1936 by R.F. Kahn), Sentry Press, New York. link

Wright, Jonathan W., 2011, Term Premia and Inflation Uncertainty: Empirical Evidence from an International Panel Dataset, *American Economic Review*, vol. 101(4): 1514-1534. link

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