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JEL Classification: E43, G12, H63.
Keywords: government debt, long-term interest rates, financial accounts.

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1. Introduction[1]

The sharp run-up in public sector debt in advanced economies is likely to be one of the most enduring legacies of the 2007-09 global financial crisis.[2] A key policy question is at what interest rates foreign and domestic investors will be willing to hold such increasing amounts of government debt. So far, the demand for government securities has been sustained by factors related to the exit from the global financial crisis, including temporary spikes in investors' preference for safe assets as well as, in some countries, unconventional monetary policies. These factors have contributed to relieve the pressure of bond supply on bond prices, thus diluting the effects of inflated public deficits over time. Eventually, however, all this newly created supply of government debt will be on the market and investors might start requiring higher yields in order to keep it in their portfolios.

To what extent could interest rates increase? To answer this question we need some measure of the slope of the demand function for sovereign debt to interest rates. The abundant empirical literature on the impact of fiscal variables on interest rates mostly relies upon reduced-form equations, which could sometimes yield biased estimates of the demand slope, especially in periods characterized by large shifts in the non-interest sensitive demand for bonds. The main contribution of this paper is to improve identification by resorting to financial accounts statistics. While remaining within a reduced-form setting, we provide an estimate of the long-term demand sensitivity by using as shifters of the demand function the financial accounts balances of three institutional sectors: households, non-financial firms and the foreign sector. We also control for foreign official reserves and the gross assets of financial institutions, following a recent strand of research highlighting the importance of gross (rather than net) capital flows in determining financial conditions.[3] We also allow for shifters of demand (e.g., sovereign ratings) that capture the degree of substitutability of sovereign debt with other assets due to credit risk concerns. Finally, we assess the potential effect of the endogeneity of debt supply to interest rates.

For a panel of 18 advanced economies over the period 1995-2011, we find that the level of public debt does matter for interest rates: an increase by one percentage point in the public debt-to-GDP ratio raises 10-year interest rates by about 2 basis points. This is in line with estimates

[1] The views expressed in the paper do not necessarily reflect those of the Banca d'Italia. All errors are the responsibility of the authors. The authors would like to thank Carlo A. Favero, Christian Upper, Gian Maria Milesi-Ferretti, Riccardo De Bonis, Giuseppe Ferrero, Pietro Tommasino, Nicola Borri, two anonymous referees, participants to the Workshop "The Sovereign Debt Crisis and the Euro Area" held at the Bank of Italy and participants to the 18th International Conference on Macroeconomic Analysis and International Finance (Crete, 29-31 May 2014) for many helpful comments.

[2] Reinhart and Rogoff (2011). See also Cecchetti, Mohanty and Zampolli (2011).

[3] Borio and Disyatat (2011) and Shin (2012).

available for the United States, but based on sample periods that do not extend beyond the mid-2000s or that usually consider fewer countries. Thus, we find that this long-term relation continues to hold also once recent crisis years are included. Moreover, our approach based on financial accounts data looks particularly well-suited to explain the stability of this relation.

The paper is structured as follows. Section 2 reviews the literature and Section 3 describes the data base. The identification framework is presented in Section 4, while Section 5 reports the econometric estimates. Some robustness checks are discussed in Section 6. Section 7 draws some conclusions.

2. The relationship between fiscal variables and interest rates in previous studies

The subject of the impact of fiscal variables on interest rates has long been a major theme in macroeconomic theory and policy debate. Considering the last thirty years, studies flourished in the eighties and early nineties when in the United States public debt relative to GDP was raising rapidly. The debate was heavily influenced by debt sustainability considerations at that time, as in Blanchard (1984), Hamilton and Flavin (1986), Bohn (1995). Research was stimulated also by the rational expectation revolution in economic theory, which led macroeconomists to investigate public debt irrelevance propositions such as the Ricardian Equivalence hypothesis within dynamic rational equilibrium models (Barro (1989)). Interest in the issue was rekindled in the early 2000s, once again in a period characterized by a large expansion of public debt in the United States. A review of the debate can be found in Gale and Orszag (2004), Ljungqvist and Sargent (2004), Engen and Hubbard (2004) and Haugh, Ollivaud and Turner (2009).

A worsening of public finances can affect medium- and long-term yields through three main channels.[4] First, if the supply of savings is not perfectly elastic, financing the budget deficit has to compete for resources with the demand for funding of the private sector, causing real interest rates to rise.[5] Second, an increase in the public debt may cause fears that even sovereign borrowers may default, leading to increased credit risk premiums on government bonds. Third, a larger deficit may

[4] See Ardagna, Caselli and Lane (2007), Balassone, Giordano and Franco (2004), Grande and Panetta (2010) and the Box "The effects of the public debt on long-term interest rates" in Banca d'Italia (2010).

[5] As pointed out by Ardagna, Caselli and Lane (2007), it is useful to distinguish between shorter- and longer-run effects. In an economy in which there is some degree of short-run nominal stickiness, a weakening in the primary fiscal balance adds to aggregate demand and leads to an increase in nominal and real short-term interest rates. Insofar as the adjustment of nominal prices is gradual and the primary fiscal balance's deterioration is perceived to be persistent, the increase in short-term interest rates feeds through medium- and long-term interest rates. In the longer run, to the extent that fiscal expansion crowds out private investment and results in a lower steady-state capital stock, it will be associated with a higher marginal product of capital and thus a higher real interest rate. For an analysis of the long-run implications of rising public debt for interest rates see Engen and Hubbard (2004).

fuel expectations of inflation or exchange-rate depreciation, with additional repercussions on interest rates.

While a strand of research focuses on sovereign credit risk premia,[6] most of the large empirical literature tries to assess the overall effect of fiscal imbalances on interest rates without distinguishing among the three channels. The econometric framework normally relies on reduced-form regressions. The fiscal variable of interest can be either public debt or public deficit; in several papers, both variables are interchangeably tried and compared. The majority of studies, however, focus on public deficit, because public debt is rarely significant at conventional confidence levels. The econometric models differ considerably also in terms of the other explanatory variables considered, functional specification, estimation method, sample period and sample countries. Three of the most representatives studies are Engen and Hubbard (2004), Laubach (2009) and Ardagna, Caselli and Lane (2007).

Engen and Hubbard (2004) provide a useful discussion of the appropriate specification of the reduced-form equation. First, they argue that, in a closed production economy with a standard Cobb-Douglas technology, public debt affects interest rates because it replaces, or crowds out, productive physical capital and thus raises the marginal productivity of capital. For this reason, an appropriate specification is to regress the *level* of interest rates on the *stock* of public debt. An alternative specification is to regress the *change* in interest rates on the *change* in public debt (i.e. government borrowing or the public deficit). A third, widely used, specification in which the *level* of interest rates is regressed on the *change* in public debt is instead less consistent with what an economic model of crowding out would suggest and can be justified only by assuming sluggish nominal price adjustment and a persistent deterioration in the fiscal position.

Second, Engen and Hubbard (2004) make clear that, in open monetary economies, the substitution of public debt for capital may be less than one-to-one because part of the supply of government bonds may be met by the demand stemming from foreign investors and the domestic central bank. Moreover, since the supply and demand of loanable funds is also affected by private sector's endogenous behaviour, an increase in government debt (other things being equal) may be offset by increases in private saving, limiting its impact on the capital stock and the interest rate. They conclude that, because economic theory is not conclusive on the size of crowding-out effects, the issue must ultimately be addressed by empirical analysis. Engen and Hubbard (2004) then provide several estimates for long-term interest rates in the United States and find that the impact of

[6] That approach is not pursued here. Reviews of recent studies related to the euro-area sovereign debt crisis can be found in, among others, Di Cesare, Grande, Manna and Taboga (2012), Favero (2013) and Giordano, Pericoli and Tommasino (2013). For earlier analyses, see Codogno, Favero and Missale (2003).

public debt is statistically significant and economically relevant: about 3 basis points for one percentage point increase in the debt-to-GDP ratio. Similar results obtain if vector autoregression analysis is carried out in order to account for dynamic effects.

Laubach (2009) argues that spot interest rates are strongly influenced by the business cycle and the associated stance of monetary policy. If during recessions automatic fiscal stabilizers raise deficits, while at the same time long-term interest rates fall due to monetary easing, deficits and interest rates may be negatively correlated even if the partial effect of deficits on interest rates—controlling for all other influences—is positive. To control for business cycle and monetary policy effects on interest rates, he claims that one should focus on the relationship between long-horizon expectations of both interest rates and fiscal variables. Accordingly, his preferred specification for the United States is one in which the endogenous variable is the 5-year-ahead 10-year forward rate and the fiscal variable is the Congressional Budget Office's 5-year-ahead projection of deficit/GDP ratio or debt-to-GDP ratio. For the 30-year 1976-2006 for which these projections are available, Laubach finds that the estimated effects of government debt and deficits on interest rates are sizable: about 3 to 4 basis points for a one percentage point increase in the debt/GDP ratio and about 25 basis points per percentage point increase in the projected deficit/GDP ratio.[7]

Ardagna, Caselli and Lane (2007) focus on the international dimension by using a panel of 16 OECD countries that covers a maximum time span from 1960 to 2002. They find that, in a simple static specification, a one-percentage-point increase in the primary deficit relative to GDP increases contemporaneous long-term interest rates by about 10 basis points. They argue that their estimates tend to understate the effects of fiscal variables on interest rates, as they use current fiscal policy variables, rather than projected variables. As for debt, they find a non-linearity: only for countries with above-average levels of debt does an increase in debt affect the interest rate. They also find that world fiscal policy is important as well: an increase in total OECD government borrowing increases each country's interest rates. However, domestic fiscal policy continues to affect domestic interest rates even after controlling for worldwide debts and deficits. They argue that the latter finding can be explained either by a less-than-perfect degree of integration of advanced economies' government bond markets or by differences in perceived government default risks.

[7] He also argues that the fact that the estimated coefficients on the deficit/GDP ratio are six to seven times as large as those on the debt/GDP ratio is consistent with the view that investors perceive increases in projected deficit/GDP ratios as highly persistent, but not strictly permanent. This argument is however challenged by Engen and Hubbard (2004), who note that public debt is also serially correlated in U.S. data, so that investors should also expect increases in federal government debt to be persistent.

The issue of the impact of fiscal variables on long-term interest rates has been recently reexamined by Baldacci and Kumar (2010), who estimate a panel of 31 advanced and emerging market economies for the period 1980–2008. Like most previous studies, the econometric framework is based on reduced-form regressions and focuses on deficits (rather than debt). For a country experiencing an increase in the fiscal deficit of 1 percentage point of GDP, long-term interest rates could rise by 20 basis points in the baseline case. Taking into account also a combination of adverse factors (e.g., unfavourable initial fiscal conditions, weak institutions, and elevated global risk aversion), the authors argue that the effect could be as high as 50 basis points and that, according to their computations, such effect would be equivalent to a calculated debt sensitivity of 5–6 basis points.

Over the last decade several studies have focused on the impact on long-term yields of the demand for government securities stemming from official reserve accumulation, institutional investors, changes in financial regulation or, more recently, large-scale asset purchases (LSAP) programs by the Federal Reserve and other central banks.[8] Beltran, Kretchmer, Marquez and Thomas (2012) find quite a sizable effect of foreign reserves.[9] They also argue that the estimated impact of the Fed's LSAP program tends to be lower, because the program was designed as a temporary stimulus program (and announced as such) and the LSAPs apparently increased the amount of uncertainty surrounding the level of future inflation, thus raising the inflation risk premium embedded in long-term interest rates. A recent strand of the literature analyses the impact of demand pressures on sovereign rates through the lens of the preferred-habitat model, in the vein of Modigliani and Sutch (1966) and Vayanos and Vila (2009). Within this stream, Greenwood and Vayanos (2014) examine how the supply and maturity structure of the US government debt affect sovereign bond yields. They find that the maturity-weighted debt-to-GDP ratio is positively related to bond yields. Following the same preferred-habitat approach, Kaminska and Zinna (2014) analyse, through a structural estimation, the impact of the demand for sovereign securities on the term structure of US real interest rates by foreign central banks and by the Federal Reserve. They find that, for a given debt supply, this demand has a considerable downward pressure on US real rates[10]. In a similar vein, Zinna (2014) gives a quantitative assessment of the price pressures exerted by institutional investors and Bank of England's quantitative easing on the UK index-linked gilts.

[8] See, e.g., Chapter VI in BIS (2006), Greenwood and Vayanos (2010), Beltran, Kretchmer, Marquez and Thomas (2012), Andritzky (2012), Kaminska and Zinna (2014), Zinna (2014) and references therein.

[9] A $100 billion (about 0.7 per cent of US GDP in 2011) increase in foreign official flows into US Treasury notes and bonds would lower the 5-year yield by roughly 20 basis points.

[10] During the years 2008-12, the LSAPs reduced real long-term rates by about 120-140 basis points.

Andritzky (2012) addresses the thorny issue of whether changes in the investor base (e.g., domestic versus non-resident investors, or leveraged versus unleveraged investors) matter. Using a new dataset on the composition of the investor base for government securities in selected G20 and euro-area countries, Andritzky estimates a reduced form regression of 10-year yields in which the explanatory variables also include the shares of government securities held by three typologies of investor: (1) non-residents; (2) private non-bank financial institutions (institutional investors); (3) public sector. He finds that a one percentage point increase in the share of government securities held by institutional investors or non-residents is associated with a reduction in yields by about 2 or 4 basis points, respectively. In order to evaluate whether causality goes from yields to holding shares (pull effect) rather than the other way round (push effect), Andritzky carries out a panel VAR analysis and finds evidence of a pull effect, that is that lower yields attract non-resident investors. He observes, however, that the result could be driven by the fact that the sample period is characterized by falling yields and increasing non-resident holdings. Finally, Andritzky also pursues a structural approach and estimates a portfolio balance model for the US, the UK, Germany and Japan. He finds that a one percentage point increase in the share of statutory or regulatory (i.e. zero or low interest-rate sensitive) holdings of government securities causes expected annual bond returns to decline by a minimum of 0.7 basis point in the UK to a maximum of 2.5 basis points in Japan.

A new perspective comes from a recent strand of the literature on the global financial crisis which emphasizes the role played by gross (rather than net) capital flows in determining financial conditions. Borio and Disyatat (2011) and Shin (2012) start from the observation that, in the global financial system, gross cross-border positions are huge and argue that a focus on current accounts and net capital flows is misleading. This is because net capital flows, by netting out the gross assets and liabilities, mask the underlying changes in gross flows and their contributions to existing stocks, including all the transactions involving only trade in financial assets, which make up the bulk of cross-border financial activity. Borio and Disyatat discuss the implications of this approach for the determination of market interest rates, mentioning as an example the downward pressure of gross capital inflows to the United States on US dollar long-term rates. Shin develops a theoretical model linking the total intermediation capacity of the banking sector and market risk premia.

Unconventional monetary policies and foreign or institutional demand for government securities certainly contribute to explain the low level of interest rates after the global financial crisis. An alternative explanation has been put forward by Krugman (2012), who argues that, because of the depressed levels of activity, business confidence in advanced economies is depressed

as well and thus the private sector does not compete with the public sector for funds. Hence, budget deficits do not necessarily lead to soaring interest rates.

3. Data

The data used for the analysis are mainly obtained from the dataset published by the "OECD *Economic Outlook*". We concentrate on national macroeconomic and fiscal aggregates, for a panel of 20 countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. We use yearly data, from 1980. Much of the analysis concentrates on a shorter time-span – from 1995 – that provides complete information on national financial accounts for all countries in the panel. All macroeconomic aggregates are measured in terms of share of GDP.

In terms of data and methodology, the closest reference paper is Ardagna et al. (2007). Our panel differs in that it contains 20 countries, adding Finland, Norway, Portugal and Switzerland. It also differs in terms of estimation samples: we analyse the periods 1980-2011 and 1995-2011, whereas they concentrate on the periods 1960-2002 and 1975-2002. Our choice is motivated by two facts: firstly, few aggregate variables are available for all countries prior to 1980, while there is an almost perfectly balanced panel after that year. Secondly, 1980 is a year of structural break for public finance aggregate relationships, both in terms of monetary policy – Volcker's designation at the Federal Reserve in 1979 – and in terms of fiscal policy – elections of Thatcher (1979) in the UK and Reagan (1981) in the USA.

Variables are listed in Table 1. YIELD_10YR and YIELD_3M are the nominal yields of the 10-year benchmark government bond and the 3-month money market interest rate, respectively, both computed on yearly basis. The inflation rate enters the regressions in two different manners: either as "expected" 10-year rate (INFLATION_10Y), on yearly basis, or as yearly "spot" rate (INFLATION). In the former case, it is subtracted from the nominal yield to compute the real 10-year yield (REAL_10Y); in the latter, it is added to the r.h.s. of the regression, either directly or subtracted from the nominal yield to compute the 3-month real rate (REAL_3M). Expected inflation rates on the 10-year horizon are available from "*Consensus Economic Forecasts*", for 15 of the 20 countries in the panel, from 1989. We have imputed those of the other countries based on a model that predicts future 10-year inflation rates based on short-term forecasts of the inflation rate and recent past rates. Details are reported in the Appendix.

Table 1: Variables

Variable Name	Description
YIELD_10Y	10-year government bond nominal yield
YIELD_3M	3-month treasury bill nominal yield
INFLATION	Current inflation rate, YoY
INFLATION_10Y	Modelled forecasted 10-year inflation, YoY
REAL_10Y	10-year government bond real yield
REAL_3M	3-month treasury bill real yield
DEBT	Gross government debt (% of GDP)
GOV_ASSET	Gross government assets (% of GDP)
WEALTH_HH	Net wealth of households (% of GDP)
WEALTH_NF	Net wealth of non-financial corporations (% of GDP)
ASSET_FF	Gross assets of the financial sector (% of GDP)
NF_DEBT	External debt (% of GDP)
RESERVES	Share of debt held as official reserves by foreign central banks (% of GDP)
AVG_LIFE	Average life to maturity of outstanding marketable debt (years)
RATING	Maximum rating grade

Data on the financial accounts positions of the main sectors of the economies in the panel are drawn from the National Financial Accounts as reported by the "*OECD Economic Outlook*". In particular, DEBT and GOV_ASSET are the gross positions of the public sector at large; WEALTH_HH, WEALTH_NF, are the net financial positions of the Households and Non-Financial Corporations sectors; ASSET_FF are the gross assets of the Financial sector whereas their gross liabilities are excluded from the analysis. NF_DEBT is the net position of the Foreign sector, as reconstructed by Lane and Milesi-Ferretti (2007).

RESERVES is the amount of a country's currency held by foreign central banks as reserves. As this is normally all invested in government bonds, we include it in our regressions as a proxy of "high powered" net-foreign-debt. Data are drawn from IMF COFER and more details on the aggregation methodology are in the appendix. AVG_LIFE is the average life to maturity of the outstanding marketable debt, measured in years, as collected by the OECD. RATING is a categorical variable that summarizes the rating of the three major rating agencies, according to the methodology outlined in the appendix.

We test for unit root in panel data using the diagnostics of Im, Pesaran and Shin (2003) and a Fisher-type test as in Choi (2001), based on augmented Dickey-Fuller independent tests on each country, combined together. Considering most of our variables of interest, we are able to reject the null hypothesis of the presence of unit roots. YIELD_10Y, YIELD_3M and INFLATION are all stationary. Only DEBT appears to be I(1), according to both tests. However, in accordance with Engen and Hubbard (2004), when considering the *level* of interest rates, it is most appropriate to compare it with the *level* of debt, thus we prefer to include this variable into the regressions in

levels rather than in first differences. Moreover, since only DEBT shows evidence of non-stationarity, we do not need to test for any cointegration among the variables. Given that, we are allowed to estimate our model with OLS. Considering the other series, which are included in our regressions as controls, we find only little evidence for non-stationarity. RESERVES, AVG_LIFE and WEALTH_NF appear to be I(0) according to the results of both tests. For GOV_ASSET, WEALTH_HH and NF_DEBT the evidence is more mixed. In fact, the non-stationarity of these three variables can be rejected according to the IPS test, but cannot according to the ADF one. Since the power of IPS test is comparatively higher than that of the ADF, we can conclude for the stationarity of these series. Finally, we fail to reject the null hypothesis of non-stationarity with both the IPS and the ADF only for the variables RATING and ASSET_FF. However, given the very short time span available for these series (only 16 data points), the power of both tests is extremely low and might invalidate our conclusions about the stationarity properties of the series. Thus we prefer to use all of them in levels[11].

4. Identification Strategy

On bond markets yields clear demand and supply. If there is an increase in the supply of bonds, its impact on the market yield depends on the slope of the demand curve. For a given increase in the supply of bonds, the higher the slope of the demand function the higher the increase in yield which is necessary to clear the market. The objective of the paper is to estimate the interest-rate sensitivity of the demand for sovereign debt for advanced countries. This is a key parameter, as it allows to quantify the potential impact, on long-term yields, of a change in the stock of sovereign debt.

The reduced-form equation for the market yield i_t at time t is

$$i_t = a_0 + a_1 * q_t + e_t, \quad (1)$$

where q_t is the outstanding amount (that is, the supply, which is assumed exogenous) of the bond at time t and e_t is a residual. The slope parameter a_1 provides an estimate of the interest rate sensitivity of demand. In order to control for changes in the demand for bonds that are unrelated to interest rates, we allow for exogenous shifts in the demand for sovereign debt. Our baseline equation is as follows:

$$yield\_10y_{i,t} = a_0 + a_1 * debt_{i,t} + a_2 * x_{i,t} + e_{i,t}, \quad (2)$$

[11] As a robustness check, given that unit-root tests may be unable to identify the presence of any structural break in the data, we performed the same tests also restricting the longitudinal sample to 2010, since the sovereign debt crisis in the euro area burst in 2011. The conclusions about stationarity reported in the main text are basically unchanged.

where $yield\_10y_{i,t}$ is the yield on 10-year government bonds for country i in period t, $debt_{i,t}$ is the debt-to-GDP ratio, $x_{i,t}$ is a set of controls and $e_{i,t}$ is a disturbance term with standard assumptions. Our parameter of interest is a_1. Depending on the specification, $yield\_10y_{i,t}$ may be measured either in real or nominal terms, with proper adjustments to the explanatory variables to make the two sides of the equation consistent. We choose to include all the variables into the regressions in levels rather than in first differences. In fact, in accordance with Engen and Hubbard (2004), the level of debt should be a more appropriate measure to evaluate the effect of government borrowing on the level of the interest rate.

The government debt supply is a key component to determine the market clearing level of interest rates. However its identification might not be as straightforward as it might first appear. In this framework the relevant debt supply corresponds to the share of the stock of government debt that can be actually exchanged on financial markets. While we consider the ratio of each country's government debt to GDP as the debt supply, this assumption can somewhat overestimate the actual supply of debt on financial markets. In fact, in many developed countries, public sector or quasi-public sector institutions hold a non-negligible part of the stock of government debt (e.g. the Social Security Trust Fund in the US or the Japan Post Holding in Japan). In this sense, since the share of government assets to GDP could be regarded as a proxy of such holdings, the inclusion of this variable among the regressors could help mitigate this potential problem.

The activity of central banks is another relevant determinant of government debt demand. Central banks usually are big players in sovereign debt markets. Moreover, in recent years their role has been on the rise, because of the LSAP programs by the Federal Reserve and similar programs by other central banks. Such programs have reduced the stock of government debt available to the market. In our empirical framework, we control for the demand for government debt stemming from central banks in two ways. First, among the right-hand side variables, we include foreign currency reserves held in government bonds[12]. Second, we take into account the gross assets of the domestic financial sector, which also include central banks assets. This is a convenient way of taking this issue into account, since there is no easy way to measure the amount of sovereign securities purchased by central banks within those programs for all of the countries in the sample. It must be underlined also that these LSAP-type programs only affect a very limited portion of the sample period (the 2009-2011 at most).

The key idea that we use to obtain identification is that of exploiting the national financial accounts (or flow of funds accounts) identity. As shifters of demand, we use the balances – i.e. the

[12] The Appendix explains how we allocate the foreign currency reserves to the government debt of euro-area countries.

difference between the value of assets and liabilities – of the financial accounts of the main institutional sectors of the economy. More specifically, we use the financial accounts identity to saturate the regression with the balances of all but one of the sectors (so as to avoid collinearity). We thus control for the net financial balances of households, non-financial firms and the foreign sector, leaving aside the net balances of financial intermediaries (see also the appendix). In order to assess whether gross (rather than net) positions also have an impact, we control for the world reserves invested in the currency of the country and for the gross assets of the financial sector. The latter variable also plays the role of proxy of the implicit burden that sovereigns might shoulder in case of financial crises.[13] Finally, we include general government's gross assets among the regressors for the reasons mentioned above. All financial balances are measured as a fraction of GDP. Table A.4 in the Appendix provides the correlation coefficients between our variable of interest – public debt – and the other control variables. As shown by those coefficients none of the chosen control variables in this framework is able to explain by itself a large portion of the variation in the Debt variable. Anyway, as one would expect, there is a certain degree of cross-country variability in the correlation coefficients.

In addition, we limit the range of possible slopes of the yield curve controlling also for the short-term rate. We also allow for other shifters of demand that capture the degree of substitutability of sovereign debt with other assets, such as the average life to maturity of the outstanding amount of government bonds and the ratings of sovereign issuers.

The above identification approach rests upon three key assumptions:

(1) *Bond supply is exogenous*. This is a strong assumption, and later on we relax it. Bond supply can be regarded as inelastic to interest rates only in the short run. In the long-run, the supply of bonds is to some degree interest-rate sensitive (the higher the interest rate the lower the supply of bonds).

(2) *The financial positions (gross assets and liabilities and/or their balance) of the institutional sectors of the economy are exogenous*. This is also not necessarily true. The portfolio choices of households and foreign investors are likely to be affected, to some degree, by the level of sovereign yields. This observation is consistent with Andritzky (2012)'s finding that declines in yields would be followed by (rather than being a consequence of) inflows of foreign investments in government bonds. Similarly, the financing decisions of non-financial corporations are affected by the level of sovereign yields. However, for the purpose of this

[13] In this light, considering financial institutions' liabilities could be considered more appropriate, but, given the high level of financial institutions' leverage, the difference between assets and liabilities is hardly significant for our purposes.

analysis, the failure of this assumption is a second-order problem. In case of endogeneity of some of these demand shifters set as control variables, our parameter of interest – the slope of the demand function (coefficient a_1 in equation (2)) – would be somewhat biased. But it would be anyway less biased than if omitting the relevant control variables. Moreover, the potential bias of the coefficient for the debt supply will be overcome through a framework allowing for IV estimations, whose set-up is explained below.

(3) *Institutional sectors' asset allocation is assumed to be constant over time and across countries*, as reflected by the fixed portfolio coefficients. This is also a simplifying assumption, because one may argue that, for example, the share of households' financial wealth held in government bonds may change. However, we have too few observations to allow for time- or country-varying coefficients.

Once our best model specifications are fixed, we are able to relax assumption (1), addressing the potential endogeneity of the bond supply, through an IV estimation. This approach also allows us to overcome any potential bias in the estimation of the slope of the demand function (see above, the discussion of assumption (2)). Therefore, the most robust results of the paper are reached through the IV estimates, while non-instrumented results should be considered just for comparison.

The supply of bonds is well likely to be influenced by the level of the interest rate: the lower this level, the higher the supply of bonds. In practice, the endogeneity problem might be not extremely relevant, because the share of the outstanding amount of government bonds that is actually interest-rate sensitive is limited. Every year, the bond supply – which can be proxied by the debt-to-GDP ratio, $debt_{i,t}$ – is in fact constrained by the realized – indeed predetermined – debt-to-GDP ratio one year before ($debt_{i,t-1}$). The fiscal room to determine the supply of bonds at time t is further constrained by the amount of interest payments on the realized government debt. Finally, the automatic stabilizers that react to the cycle would further reduce the endogeneity of the supply of debt.

In order to correctly address the endogeneity problem, we then isolate the share of the debt supply that is actually discretionary and use the strictly exogenous debt supply as instrumental variable for the actual debt-to-GDP ratio in a two-stage least-squares fixed-effect estimation. The exogenous component of the debt supply – $debt\_ex_{i,t}$ – is calculated as follows:

$$debt\_ex_{i,t} = debt_{i,t-1} + int\_pay_{i,t} + aut\_stab_{i,t}$$

where $debt_{i,t-1}$ is the realized debt-to-GDP ratio at time *t-1*, int_pay_{it} is the ratio of interest payments due at time *t* to GDP and aut_stab_{it} is the share of the primary balance attributable to non-discretional automatic stabilizers. The latter variable, being a typical cyclical component, is calculated as the difference between the realized primary balance of each country and its cyclically-adjusted value, as calculated by the OECD.

The baseline estimation method for our panel regression is ordinary least squares with country fixed effects and robust standard errors. For the reduced-form equation (2), that makes use of financial accounts variables, we have data for 18 countries over the period 1995-2011, totalling 292 observations (about 16 observations per each country) [14]. When considering the IV estimates, we rely on a two-stage least-square within estimator (IV-FE) method, or on a first-differenced GMM, depending on the instruments.

5. Estimation Results

Our main results are summarized in Tables 2 and 3, in which columns differ from one another either in terms of the sample period, the set of control variables or the estimation method.

Right-hand side variables always include a 3-month (real or nominal) interest rate, to control for parallel shifts of the yield curve. The underlying assumption that this rate is uncorrelated with the error term is based on the fact that this is a policy rate set by the central bank. The other explanatory variables only capture movements of the slope of the yield curve.

Let's start with the estimates that assume that the bond supply is exogenous. The main results are presented in columns 1 and 2 of Table 2. Starting from the specification shown in column (1), the interest rate sensitivity of the demand for government bonds is quite high: an increase of one percentage point in the public debt-to-GDP ratio leads to an increase in the 10-year real rate on the order of 5 basis points. Moreover, the R^2 of the regression is fairly good and almost all of the other coefficients are significant and have the correct sign. An increase of one percentage point of GDP in general government's gross assets or households' net financial wealth lowers the 10-year real interest rate by about 3 basis points. A reduction of one percentage point of GDP in the net debt of non-financial firms or an increase of the same magnitude in the net foreign debt

[14] We drop New Zealand and Switzerland from the analysis, since financial accounts data for these two countries are missing.

Table 2

Ten-year interest rates of advanced economies: Estimates of the sensitivity of demand (1)

	[1]		[2]		[3]		[4]	
Public debt (% GDP)	0.0480	[0.00]	0.0309	[0.00]	0.0481	[0.00]	0.0298	[0.01]
Inflation (%)	0.4502	[0.00]	0.4060	[0.00]				
3-month real rate (%)	0.4977	[0.00]	0.4999	[0.00]				
3-month nominal rate (%)					0.4840	[0.00]	0.4691	[0.00]
General gov't assets (% GDP)	-0.0286	[0.00]	-0.0242	[0.00]	-0.0282	[0.00]	-0.0228	[0.00]
Househ.ds' net fin. wealth (% GDP)	-0.0287	[0.00]	-0.0240	[0.00]	-0.0279	[0.00]	-0.0223	[0.00]
Non-fin. corp.ns' net wealth (% GDP)	-0.0129	[0.03]	-0.0090	[0.06]	-0.0123	[0.06]	-0.0080	[0.11]
Net foreign debt (% GDP)	-0.0067	[0.16]	-0.0064	[0.12]	-0.0057	[0.28]	-0.0042	[0.36]
Foreign off. reserves (% GDP)	-0.1480	[0.00]	-0.1307	[0.00]	-0.1514	[0.00]	-0.1363	[0.00]
Fin. corp.ns' assets (% GDP)	-0.0002	[0.63]	-0.0006	[0.21]	-0.0002	[0.69]	-0.0005	[0.21]
Average life to maturity (years)	-0.2165	[0.03]	-0.1643	[0.04]	-0.2267	[0.02]	-0.1837	[0.02]
AA + (dummy)			0.3361	[0.02]			0.4210	[0.02]
AA (dummy)			0.5205	[0.02]			0.6476	[0.01]
AA - (dummy)			1.6263	[0.00]			1.7559	[0.00]
A + (dummy)			1.9507	[0.00]			2.0284	[0.00]
BBB + (dummy)			5.0045	[0.00]			4.8819	[0.00]
BB + (dummy)			6.4117	[0.00]			6.3771	[0.00]
Constant	5.4568	[0.00]	5.9523	[0.00]	5.4026	[0.00]	5.6213	[0.00]
Country Dummies	Yes		Yes		Yes		Yes	
R-square	0.368		0.516		0.371		0.522	
Sample period	1995-2011		1995-2011		1995-2011		1995-2011	
Number of countries	18		18		18		18	
Number of observations	292		292		292		292	

Legend of model specification: [1] Heterogeneous time trend and economic restrictions; [2] Heterogeneous time trend, economic restrictions and ratings; [3] Heterogeneous time trend and economic restrictions; [4] Heterogeneous time trend, economic restrictions and ratings.

(1) Panel estimates with fixed effects, run on yearly data. For each specification, the table shows coefficient estimates and, in square bracket, the related *p*-values.

position[15] lower the 10-year real rate by about 1 basis point. A much stronger effect is found for foreign official reserves (a component of the net foreign debt position): one percentage point increase in the ratio of foreign reserves to GDP leads to a reduction of the 10-year real rate by 15 basis points. An increase in financial corporations' gross assets is also associated with a reduction of the 10-year real rate, but in this specification the effect is not statistically significant. Finally, a one-year increase in the average life to maturity of the outstanding amount of government bonds implies a decline of almost 22 basis points in the 10-year real rate.

The degree of substitutability between government bonds and alternative asset classes (e.g., corporate bonds and listed shares) is affected by changes in the creditworthiness of sovereign borrowers – i.e. by changes in sovereign credit risk. In the specification shown in column (1), the only variable that accounts for investors' sovereign debt sustainability concerns, in addition to the level of public debt as such, is the average life to maturity of the existing stock of bonds. The specification presented in column (2) of Table 2 tries to better capture investors' perception of the soundness of sovereign borrowers. It does so by including sovereign ratings dummies among the control variables, under the working hypothesis that the grades assigned by rating agencies to government bonds can be a rough indicator of financial markets participants' perceptions of sovereign credit risk. In the specification shown in column (2), rating dummies turn out to have a strong effect on the 10-year real rate. Their coefficients are significant and proportional to the degree of riskiness associated with the rating grade. A comparison of column (2) with column (1) indicates that the inclusion of rating dummies tends to make demand sensitivity lower than in the specification without rating dummies: one additional percentage point of public debt-to-GDP ratio increases the 10-year real rate by about 3 (instead of 5) basis points. The other coefficients are all remarkably stable, although most of them are a bit smaller in magnitude.

In column (3) and column (4) the short-term real rate and the inflation rate are replaced with the nominal short rate. Column (3) is without rating dummies. The demand sensitivity is about 5 basis points. Column (4) also includes rating dummies. The demand sensitivity is about 3 basis points, as in column (2).

A key aspect of demand sensitivity estimates is the potential endogeneity of the supply of debt. As explained in Section 4, this is addressed through instrumental variables estimates. This approach also allows to address the potential bias of the coefficient for the slope of the demand, in case of endogeneity of some control variables. The estimates are shown in Table 3 and are the main results of the paper. Equations (1) and (2) of Table 2 are replicated with different instruments,

[15] The coefficient of the net foreign debt position is not significant, however. We are grateful to Philip Lane and Gian Maria Milesi-Ferretti for providing these data. The original reference is Lane and Milesi-Ferretti (2007).

Table 3

Estimations with instrumental variables (1)

	Memorandum items (from Table 2):															
	[1]		*[2]*		[1]		[2]		[1]		[2]		[1]		[2]	
Estimation Method	*FE*		*FE*		FD-GMM		FD-GMM		IV-FE		IV-FE		FD-GMM		FD-GMM	
Public debt (% GDP)	0.0480	[0.00]	0.0309	[0.00]	0.0480	[0.050]	0.0306	[0.00]	0.0442	[0.00]	0.0248	[0.00]	0.0391	[0.00]	0.0194	[0.03]
Inflation (%)	0.4502	[0.00]	0.4060	[0.00]	0.4452	[0.00]	0.4047	[0.00]	0.4512	[0.00]	0.4077	[0.00]	0.4527	[0.00]	0.4747	[0.00]
3-month real rate (%)	0.4977	[0.00]	0.4999	[0.00]	0.4867	[0.00]	0.4940	[0.00]	0.4987	[0.00]	0.4961	[0.00]	0.5056	[0.00]	0.5163	[0.00]
3-month nominal rate (%)																
General gov't assets (% GDP)	-0.0286	[0.00]	-0.0242	[0.00]	-0.0287	[0.00]	-0.0241	[0.00]	-0.0259	[0.00]	-0.0205	[0.00]	-0.0256	[0.00]	-0.0191	[0.01]
Househ.ds' net fin. wealth (% GDP)	-0.0287	[0.00]	-0.0240	[0.00]	-0.0284	[0.00]	-0.0238	[0.00]	-0.0264	[0.00]	-0.0209	[0.00]	-0.0324	[0.00]	-0.0191	[0.00]
Non-fin. corp.ns' net wealth (% GDP)	-0.0129	[0.03]	-0.0090	[0.06]	-0.0128	[0.01]	-0.0090	[0.03]	-0.0105	[0.02]	-0.0063	[0.11]	-0.0127	[0.02]	-0.0031	[0.56]
Net foreign debt (% GDP)	-0.0067	[0.16]	-0.0064	[0.12]	-0.0059	[0.17]	-0.0060	[0.11]	0.0044	[0.36]	-0.0035	[0.40]	-0.0038	[0.49]	-0.0023	[0.67]
Foreign off. reserves (% GDP)	-0.1480	[0.00]	-0.1307	[0.00]	-0.1492	[0.00]	-0.1302	[0.00]	-0.1414	[0.00]	-0.1216	[0.00]	-0.1356	[0.00]	-0.0953	[0.00]
Fin. corp.ns' assets (% GDP)	-0.0002	[0.63]	-0.0006	[0.21]	-0.0002	[0.58]	-0.0006	[0.18]	0.0002	[0.67]	-0.0006	[0.16]	-0.0002	[0.75]	-0.0001	[0.75]
Average life to maturity (years)	-0.2165	[0.03]	-0.1643	[0.04]	-0.2150	[0.01]	-0.1673	[0.02]	-0.2146	[0.00]	-0.1606	[0.01]	-0.222	[0.02]	-0.1913	[0.02]
AA + (dummy)			0.3361	[0.02]			0.1732	[0.01]			0.4181	[0.02]			0.2710	[0.00]
AA (dummy)			0.5205	[0.02]			0.1897	[0.01]			0.6705	[0.01]			0.3199	[0.00]
AA - (dummy)			1.6263	[0.00]			0.3412	[0.00]			1.7619	[0.00]			0.3795	[0.00]
A + (dummy)			1.9507	[0.00]			0.3964	[0.00]			2.1219	[0.00]			0.4603	[0.00]
BBB + (dummy)			5.0045	[0.00]			0.6236	[0.00]			5.2150	[0.00]			0.6094	[0.00]
BB + (dummy)			6.4117	[0.00]			0.5874	[0.00]			6.7157	[0.00]			0.6265	[0.00]
Constant	5.4568	[0.00]	5.9523	[0.00]	5.4505	[0.00]	5.9542	[0.00]	5.4879	[0.00]	5.9908	[0.00]	6.3858	[0.00]	5.9854	[0.00]
Country Dummies	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
R-square	0.368		0.516						0.389		0.548					
Sample period	1995-2011		1995-2011		1995-2011		1995-2011		1995-2011		1995-2011		1995-2011		1995-2011	
Number of countries	18		18		18		18		18		18		18		18	
Number of observations	292		292		292		292		292		292		292		292	
Instruments					Debt (t-1)		Debt (t-1)		Debt_ex		Debt_ex		Debt_ex; Debt_ex (t-1)		Debt_ex ; Debt_ex (t-1)	

Legend of model specification: [1] Heterogeneous time trend and economic restrictions; [2] Heterogeneous time trend, economic restrictions and ratings;
(1) Panel estimates with instrumental variables, run on yearly data. For each specification, the table shows coefficient estimates and, in square bracket, the related *p*-values.

namely (a) lagged debt (which is not strictly exogenous, but can be considered predetermined); (b) exogenous debt (as specified in Section 4) and (c) exogenous debt together with the lagged value of debt. With the strictly exogenous debt – case (b) – equations (1) and (2) can be estimated with a two-stage least-square within estimator (IV-FE) method, while for cases (a) and (c), the equations are estimated with a first-differenced GMM with robust errors.

The coefficients for the debt variable range from 4 to 5 basis points for equation (1), without rating dummies, and from 2 to 3 basis points for equation (2) that includes rating dummies. These results are broadly in line with the baseline estimations – respectively, 5 and 3 b.p. for equations (1) and (2) in Table 2. The slight reduction in the magnitude of the coefficient in both specifications is consistent with the theory, which predicts a negative relation between the level of the interest rate and the supply of bonds. Moreover, the small change in the coefficients from the baseline strict-exogeneity estimations points to a limited sensitivity of the debt supply to interest rates. Considering the control variables, most of the conclusions stated in the above paragraphs continue to hold in this setting, pointing to a reliable specification.

In particular, despite being quite strong, our restriction on demand shifters fits the data very well and we are able to quantify the effects of several factors in a consistent way. The largest coefficient is associated with official foreign exchange reserves. This agrees with the view that the sizable stock of reserves accumulated by emerging market countries since the late nineties (due to currency intervention, current account surpluses and other factors) has exerted a strong downward pressure on the yields of advanced economies (Bernanke, 2005). Other factors having an impact on the demand for sovereign debt are households' and non-financial corporations' net financial wealth and general government's holdings of financial assets. It is worth underlying that the net financial wealth of non-financial corporations is usually negative and is actually a debt. According to the results, this net wealth is associated with a negative coefficient, which means that an increase in the net debt of financial corporations is associated with higher yields on government debt. As expected, the government debt supply can be crowded out by an increased supply of alternative assets, like corporate bonds. Analogously, the negative coefficient for households' net financial wealth shows that an increase in the stock of savings of the private sector can put downward pressure on government debt yields. On the other hand, the holdings of financial assets by the general government are associated with lower yields as these assets decrease the net debt of the general government but can also stand against future government implicit guarantees (e.g. pension schemes, etc.). The coefficient for the net foreign debt position (which takes into account all capital flows, including official foreign exchange reserves) is negative, even if it is not significant. In this view, a higher net foreign debt, arising from a net inflow of foreign funds, could be associated with lower

yields, as these funds would be allocated across the different assets available in the economy, among which the government debt is one of the main ones.

The coefficient associated with banks' gross assets is not significant. This is not necessarily inconsistent with the hypothesis that gross (rather than net) capital flows matter, for two reasons. First, the acceleration in cross-border bank assets started around the middle of the 2000s[16] and thus weighs on a rather small fraction of our sample period. Second, gross (as opposed to net) flows effects are also captured by official reserves.

As for public debt sustainability indicators, which allow us to control for changes in financial markets' perception of sovereign credit risk, we find that the average maturity of public debt – that also accounts for the refinancing risk of the debt stock – does matter. A higher average life to maturity of the debt stock (measured in years) is associated with lower yields. The results for ratings generally associate higher yields to lower credit rating grades, as expected.

6. Robustness

Our main robustness concern regards the reliability of financial accounts in accurately capturing demand shifts. As explained in Section 4, we saturated the equations with the net balances of the financial accounts identity of all institutional sector but one (that of financial intermediaries) and also included gross assets of financial intermediaries.

To test the robustness of our findings to this specification we run several replications of equations (1) and (2) including the net financial balance of financial intermediaries and in turn the gross assets of any other institutional sector. The results – shown in the Appendix (Table A.5) – are robust to changes in the chosen financial accounts specification. The debt coefficient remains significant and changes its value only marginally. The specification shown in Tables 2 and 3 appears to be the most meaningful economically.

In our main specification, we choose not to include time dummies. Indeed time dummies imply a country-invariant time effect, which is obviously not the case in such a panel. Therefore, the common time trend is replaced with country-level time trends based on our economic restriction, namely that shifts in the demand schedule are driven by changes in the balances of the financial accounts of the main institutional sectors of the economy (as explained in Section 4). This amounts to give each country its own "time trend", driven by the fundamentals of each country's financial structure. Including the time dummies, together with our economic restriction, would incur the risk of double counting the time effect, with a potential result of collinearity. Moreover, given

[16] See, e.g., Figure 5 in Shin (2012).

the limited number of observations in our main specifications (292 observations), we prefer a more parsimonious model, whereas the inclusion of time dummies would greatly reduce its degrees of freedom. Nevertheless, as a robustness check, we also run our main specification (with and without rating dummies) including time dummies as well. The results do not change qualitatively.

We conducted several other robustness checks (not shown). We thoroughly looked for non-linearities (trying many different parameterizations, like interactions among regressors, the squared level of debt and thresholds in the level of debt-to-GDP ratio, to name just a few), but we did not find any type of non-linear effect. This is in contrast with Ardagna et al. (2007), which however does not control for ratings. We also tried many different types of forward-looking variables (e.g., expected short- and long-term inflation and expected fiscal deficits one- and two-year forward), but we didn't get any significant gain in terms of accuracy of the estimates.

7. Conclusions

We obtain an estimate of the long-term slope of the demand function for government securities in advanced economies. We use panel data regressions on 18 countries covering the seventeen years from 1995 to 2011. The sample period includes not only the low interest rates phase in the mid-2000s but also the further downward trend in market yields observed in the three-year 2009-11 after the most acute phase of the global financial crisis. We find that, in the long run, each percentage point increase in the ratio of public debt to GDP raises 10-year rates by 2 basis points. This is a sizeable effect, considering that, in the three-year 2009-11, the median value of the average annual change in the debt-to-GDP ratio was equal to almost 6 percentage points in the 18 countries considered and 7 percentage points in the G7 countries. The fact that long-term interest rates actually declined for several countries in the sample, while the debt-to-GDP ratio increased in 2009-11, can be explained through exogenous shocks to the demand function that are accurately considered in our framework through a broad set of controls.

Previous estimates of the demand sensitivity of government debt in the United States are in line with our results. Most of those estimates, however, are based on sample periods that do not extend beyond the mid-2000s. Moreover, our empirical framework is able to identify the long-term sensitivity of the demand for government bonds, because it controls for short-term shifts in the demand and also addresses the potential endogeneity of debt supply to interest rates.

The use of financial accounts data also allows us to take into account in a consistent way some factors that have been said to affect market yields since the 2000s, namely the accumulation of foreign official reserves by emerging market and oil exporting countries and changes in financial

regulation and accounting. Our results give insights also on the interest rate effects of unconventional monetary policies, although the latter matter only in the last two years of the sample and for a limited number of countries. We also find evidence that gross (rather than net) positions do have an impact on interest rates. These results are robust to the use of different combinations of financial accounts data as right-hand side variables. Finally, we control for changes in the perceived riskiness of government bonds by using debt sustainability indicators (average life to maturity and sovereign ratings).

In conclusion, public debt does affect long-term interest rates and its potential drag on its own sustainability through higher interest rates should not be overlooked. It must be underlined, however, that the interest rate burden and other costs of public debt have always to be carefully weighed against the overall short- and long-run benefits of government intervention, especially in depressed economies.

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Appendix

In this Appendix we provide further evidence of the methodologies we use to assemble the data for some variables. All the macroeconomic and fiscal variables did not need any special care, except presenting the main fiscal variables as a share of GDP, while the long-term expected inflation, the share of debt held in foreign official reserves and the rating variables needed some additional manipulation. Moreover, some further explanation on financial account variables might be useful.

Macroeconomic Variables

The macroeconomic and fiscal variables data were collected from the n. 88 OECD Economic Outlook. Here is presented the list of the main variables selected, with their OECD code and definition.

Table A.1: Macroeconomic and Fiscal Series

Code	Description
CBGDPR	Current account balance, as a percentage of GDP
CPIH_YTYPCT	Consumer price index, harmonised, year-on-year growth
EXCHER	Real effective exchange rate, constant trade weights (New)
GAP	Output gap of the total economy
GDPV	Gross domestic product, volume, market prices
GFAR	General government gross financial assets, as a percentage of GDP
GGFL	General government gross financial liabilities, value
IRL	Long-term interest rate on government bonds
IRS	Short-term interest rate
NLG	Government net lending, value

Expected long-term inflation

The most comprehensive and reliable data source of forecasts of macroeconomic indicators is provided by Consensus Economics, from 1989 onwards. Regarding short-term forecasts, CE provides monthly updates of forecasts for the year under review and one year ahead, for all the countries of the sample[17].

However data for 10-year ahead forecasted inflation are provided only for a subset of 12 countries out of the 20 we are interested in (Canada, France, Germany, Italy, Japan, the UK and the US from 1990; the Netherlands, Spain and Sweden from 1995 and Norway and Switzerland from 2000)[18]. We specify a regression model able to explain the 10-year forecasted inflation for these 12 countries. Then, through the regression coefficients, we build a modelled 10-year forecasted inflation variable for all the countries of the sample. We estimate a fixed-effect panel regression model, following the same econometric restrictions about the robustness of the errors as in the main regression in Section 5. The model specifications we estimate are shown in Table A.2. Trying to hold the model as simple as possible, we restricted the set of regressors to realized and short-term forecasted values of inflation, while the regressand is obviously the 10-year forecasted inflation.

[17] These forecasts structure is followed from February onwards, as the January release reports data for the year before and the one under review. Collecting short-term data we chose the forecasts released every February.

[18] Actually, the average 10-year inflation forecast is not readily available. Consensus Economics provides semi-annual forecasts of inflation 1-, 2-, 3-, 4-, 5-, and the average 6-to-10-year ahead. Thus, we have averaged the data through every maturity of the reference horizon and between the two issues of every year.

Our estimation results are presented in Table A.2. According with the AIC and BIC criteria, we can consider a simple model with only the 1-year forecasted inflation as regressor as our preferred specification, as in eq. (3).

Table A.2: 10-Year Ahead Inflation Forecasts Estimation

	Dep. Var. INFLATION_10Y Time Sample (1990-2010)			
	(1) OLS	(2) OLS	(3) OLS	(4) OLS
INFL_CUR_FCAST	0.480 (9.96)**	-0.036 (-1.07)		
INFL_1Y_FW		0.787 (11.69)**	0.746 (20.40)**	0.775 (17.40)**
INFLATION				-0.027 (-1.27)
CONSTANT	1.241 (12.60)**	0.609 (6.91)**	0.624 (7.97)**	0.616 (7.58)**
Adjusted R^2	0.73	0.91	0.91	0.91
F-Test	99.13	286.70	416.35	202.95
AIC	183.10	-89.71	-89.72	-90.49
BIC	186.48	-82.95	-86.34	-83.74
N. of obs.	217	217	217	217

As a robustness check, we plugged realized and expected values of GDP growth in our regressions. However GDP growth does not appear to play a statistically significant role in shaping long-term inflation expectations. Thus we maintain eq. (3) as our preferred model specification. From its coefficients, we can build the modelled 10-year ahead inflation forecasts.

Financial Accounts

Financial balance sheets data are collected from the OECD Database "Financial Accounts", which belongs to the System of National Accounts (SNA 93). According to the OECD definition, the financial balance sheets "record the stocks of assets and liabilities held by the institutional sectors, and give a picture of their net worth, at the end of the accounting period"[19]. Even though data are available from 1970 onwards, we find adequately populated series for the 20 countries of our sample from 1995 onwards[20]. However New Zealand did not provide this set of data with continuity, thus restricting our sample to 19 countries when using financial accounts variables.

The institutional sectors, the economy is broke-down in, are: non-financial corporations (S11), financial corporations (S12), general government (S13), households and non-profit institutions serving households (S14-15). These sectors sum up to make the total economy sector (S1). Finally, another sector is added, accounting for the rest of the world sector (S2), which reflects asset and liabilities of non-residents. Similarly to the balance of payment identity, any net worth value of the total economy sector is balanced by a net worth value of opposite and equal size for the rest of the world, such that the following identity is always true:

$$NetWorth^{S11} + NetWorth^{S12} + NetWorth^{S13} + NetWorth^{S14\text{-}15} + NetWorth^{S2} = 0$$

[19] Further details can be found at:

http://www.oecd.org/LongAbstract/0,2546,en_2649_34245_37366237_1_1_1_1,00.html. For a recent analysis based on these data, see Bruno, De Bonis and Silvestrini (2012).

[20] 1995 is the year of the introduction of the ESA95 standard, which makes the national accounts data comparable across countries. Only few countries provide data prior to this year.

We chose to use consolidated financial accounts. The reliability of consolidated accounts more accurately represents the financial position of the various sectors in the economy.

Debt held in foreign currency official reserves

Since data accounting for the share of government debt held by foreign central banks, through the allocation of their official foreign exchange reserves, are not available, a proxy variable mimicking this phenomenon is necessary. We rely on the IMF COFER database, which provides the currency composition of official foreign exchange reserves being held globally[21]. Moreover, these reserves data do not include holdings of a currency by its issuing country. Thus this dataset can serve as the best proxy for the demand of sovereign debt from foreign central banks.

Only the following currencies are identified in the database: US Dollar, Euro, Pound Sterling, Japanese Yen and Swiss Franc; and other currencies[22]. Thus we are able to attribute the share of foreign exchange reserves invested in sovereign debt only for four countries: the US, the UK, Japan and Switzerland. For the remainder of the sample – euro-area countries and others – we need some manipulation of the data. For the euro-area countries in our sample we choose to assign to each country a share of the reserves in euros equal to its share of the euro-area GDP[23]. It is hard to imagine an objective criterion able to account for the flight-to-safety phenomenon that affected the euro-denominated debt market in the aftermath of the global financial crisis of 2007-2010. Thus, our data might be slightly underestimated for core euro-area countries (e.g. Germany, France, etc.) and slightly overestimated for peripheral countries (e.g. Ireland, Portugal, etc.). For the remainder of the sample we follow a similar approach. The "other currencies" series is broken down according to the share of each country's GDP, relative to world GDP.

Rating Grades

Rating grades are collected from the three main rating agencies (Standard & Poor's, Moody's and Fitch Ratings), made comparable through the commutation criteria shown in Table A.3, and associated with the corresponding number, as reported in the Rank column, such that every country have three numbers, corresponding to three ratings, for every year. The lowest number, corresponding to the highest rating grade, is selected for every country and year. In the 1995-2010 sample the highest rating grade is always no less than 4 (that is AA-/Aa3/AA-).

[21] For further details, see: http://www.imf.org/external/np/sta/cofer/eng/index.htm

[22] Before the introduction of the euro in 1999, the COFER database also identified: Deutsche Mark, French Franc, Netherlands Guilder and the European Currency Unit (ECU).

[23] For the years preceding the introduction of the euro (1995-1998), when three national currencies and the ECU were identified, we choose a similar criterion. Deutsche Mark, French Franc and Netherlands Guilder are attributed to Germany, France and the Netherlands. In addition, a share of ECU holdings is assigned to each EU country according to its share of EU GDP.

Table A.3: Rating grades conversion table

S&P	Moody's	Fitch	Rank
AAA	Aaa	AAA	1
AA+	Aa1	AA+	2
AA	Aa2	AA	3
AA-	Aa3	AA-	4
A+	A1	A+	5
A	A2	A	6
A-	A3	A-	7
BBB+	Baa1	BBB+	8
BBB	Baa2	BBB	9
BBB-	Baa3	BBB-	10
BB+	Ba1	BB+	11
BB	Ba2	BB	12
BB-	Ba3	BB-	13
B+	B1	B+	14
B	B2	B	15
B-	B3	B-	16
CCC+	Caa1	CCC+	17
CCC	Caa2	CCC	18
CCC-	Caa3	CCC-	19
CC	Ca	CC	20
C	C	C	21

Table A.4: Correlation Matrix between Government Debt and the chosen control variables

	Variable						
Country	GOV_ASSET	WEALTH_HH	WEALTH_]	ASSET_FF	NF_DEBT	RESERVES	AVG_LIFE
Australia	-0.33	-0.63	0.66	-0.81	-0.31	0.44	-0.40
Austria	0.94	0.36	-0.08	0.25	-0.68	0.49	0.07
Belgium	0.19	0.75	0.32	-0.89	-0.40	-0.65	-0.57
Canada	0.01	0.23	0.20	-0.51	0.94	0.45	-0.82
Denmark	0.28	-0.55	0.77	-0.75	0.59	0.35	-0.23
Finland	0.73	-0.46	0.23	-0.25	0.13	-0.44	0.66
France	0.57	0.52	-0.49	0.80	0.81	0.88	0.68
Germany	0.45	0.85	-0.31	0.74	-0.88	0.90	0.53
Ireland	0.69	-0.11	-0.69	0.77	0.91	0.83	-0.12
Italy	0.15	-0.16	0.52	-0.32	-0.40	-0.34	-0.48
Japan	0.92	0.97	0.76	0.63	-0.91	0.86	0.31
Netherlands	0.77	0.42	-0.25	-0.54	-0.45	-0.40	0.20
Norway	0.84	-0.39	-0.77	0.59	-0.54	-0.08	-0.34
New Zealand	-0.56	-	-	-	-	-	-
Portugal	0.27	-0.50	-0.65	0.78	0.80	0.89	0.65
Spain	0.19	0.35	0.64	-0.51	-0.50	-0.37	-0.72
Sweden	-0.31	-0.60	0.67	-0.86	0.92	0.07	-0.50
Switzerland	0.87	-	-	-	-	-	-
UK	-0.03	-0.12	0.27	0.76	-0.23	0.80	0.56
USA	0.76	-0.18	0.49	0.48	0.36	0.76	-0.42
Total	0.37	0.04	0.13	0.02	0.01	0.30	-0.05

Table A.5

Robustness: Estimates of the sensitivity of demand through different breakdowns of the financial accounts identity (1)

Gross assets included as regressors (% GDP)												
	Househ.ds' assets [1]		Non-fin. corp.ns' assets [1]		Foreign assets [1]		Househ.ds' assets [2]		Non-fin. corp.ns' assets [2]		Foreign assets [2]	
Public debt (% GDP)	0.0330	[0.01]	0.0376	[0.01]	0.0438	[0.00]	0.0197	[0.03]	0.0218	[0.03]	0.0266	[0.00]
Inflation (%)	0.4233	[0.00]	0.4617	[0.00]	0.4674	[0.00]	0.3698	[0.00]	0.4008	[0.00]	0.4162	[0.00]
3-month real rate (%)	0.4655	[0.00]	0.4885	[0.00]	0.4946	[0.00]	0.4798	[0.00]	0.4889	[0.00]	0.4980	[0.00]
3-month nominal rate (%)												
General gov't assets (% GDP)	-0.0116	[0.02]	-0.0168	[0.00]	-0.0221	[0.00]	-0.0121	[0.01]	-0.0149	[0.00]	-0.0172	[0.00]
Househ.ds' assets (% GDP)	-0.0191	[0.00]					-0.0183					
Househ.ds' net fin. wealth (% GDP)			-0.0178	[0.00]	-0.0247	[0.00]		[0.00]	-0.0155	[0.00]	-0.0207	[0.00]
Non-fin. corp.ns' assets (% GDP)			-0.0014	[0.78]					-0.0051	[0.20]		
Non-fin. corp.ns' net wealth (% GDP)	-0.0022	[0.62]			-0.0078	[0.11]	-0.0020	[0.58]			-0.0049	[0.08]
Foreign assets (% GDP)					-0.0005	[0.57]					-0.0014	[0.09]
Net foreign debt (% GDP)	0.0051	[0.28]	0.0043	[0.28]			0.0015	[0.70]	0.0013	[0.58]		
Foreign off. reserves (% GDP)	-0.0842	[0.06]	-0.1393	[0.01]	-0.1337	[0.00]	-0.0837	[0.02]	-0.1138	[0.00]	-0.1075	[0.00]
Fin. corp.ns' assets (% GDP)												
Fin. corp.ns' net wealth (% GDP)	-0.0036	[0.72]	-0.0008	[0.92]	-0.0052	[0.44]	-0.0013	[0.86]	0.0005	[0.94]	-0.0043	[0.45]
Average life to maturity (years)	-0.1181	[0.21]	-0.1887	[0.04]	-0.1992	[0.05]	-0.1011	[0.23]	-0.1492	[0.05]	-0.1418	[0.09]
AA + (dummy)							0.2119	[0.16]	0.3225	[0.03]	0.3612	[0.01]
AA (dummy)							0.4605	[0.13]	0.5765	[0.01]	0.6380	[0.00]
AA - (dummy)							1.3928	[0.00]	1.7053	[0.00]	1.7443	[0.00]
A + (dummy)							2.0498	[0.00]	2.1132	[0.00]	2.1488	[0.00]
BBB + (dummy)							5.1739	[0.00]	5.2750	[0.00]	5.3083	[0.00]
BB + (dummy)							6.6748	[0.00]	6.6527	[0.00]	6.4626	[0.00]
Constant	6.0700	[0.00]	5.4568	[0.00]	5.2389	[0.00]	6.7892	[0.00]	6.0946	[0.00]	6.7892	[0.00]
Country Dummies	Yes		Yes		Yes		Yes		Yes		Yes	
R-square	0.436		0.418		0.399		0.564		0.583		0.527	
Sample period	1995-2011		1995-2011		1995-2011		1995-2011		1995-2011		1995-2011	
Number of countries	18		18		18		18		18		18	
Number of observations	292		292		292		292		292		292	

Legend of model specification: [3] Heterogeneous time trend and economic restrictions; [4] Heterogeneous time trend, economic restrictions and ratings; Panel estimates with fixed effects, run on yearly data. For each specification, the table shows coefficient estimates and, in square bracket, the related *p*-values

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