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# Long-run and short-run determinants of sovereign bond yields in advanced economies

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ABSTRACT

We analyze determinants of sovereign bond yields in 22 advanced economies over the 1980–2010 period using panel cointegration techniques. The application of the cointegration methodology allows distinguishing between long-run (debt-to-GDP ratio, potential growth) and short-run (inflation, short-term interest rates, etc.) determinants of sovereign borrowing costs. We find that in the long run, government bond yields increase by about 2 basis points in response to a 1 percentage point increase in government debt-to-GDP ratio and by about 45 basis points in response to a 1 percentage point increase in the potential growth rate. In the short run, sovereign bond yields deviate from the level determined by the long-run fundamentals, but about half of the deviation adjusts in one year. When considering the impact of the global financial crisis on sovereign borrowing costs in euro area countries, the estimations suggest that spreads against Germany in some European periphery countries exceeded the level determined by fundamentals in the aftermath of the crisis, while some North European countries have benefited from “safe-haven” flows.



## 1. Introduction

What factors affect the interest rate that governments pay to borrow in the long run? The economics literature suggests that borrowing costs depend on the fundamental conditions in the economy, and especially the fiscal accounts. For example, as government debt rises, sovereign bond

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yields should go up in recognition of the higher risk (default, monetization-driven depreciation and inflation) carried by investors holding government securities.

The long-run relationship between sovereign bond yields and macroeconomic fundamentals can break down in the short run, especially during periods of financial stress. For example, despite the piling up of general government debt in the United States in the aftermath of the global financial crisis, U.S. bond yields have been trending downward. Conversely, despite a relatively lower initial level of general government debt, sovereign borrowing costs in some euro area countries such as Spain have persistently exceeded those of more highly indebted countries such as the United Kingdom.

This behavior suggests the need to distinguish between long-run and short-run determinants of borrowing costs. In this paper, we attempt to shed light on this issue for a sample of advanced economies. Our conjecture is that sovereign bond yields can temporarily deviate from their long-run equilibrium level driven by short-run factors (such as monetary policy). We use the panel cointegration methodology, which has two main advantages over the fixed effects (FE) estimator employed in the vast majority of existing studies.[1] First, it allows the coefficients of short-run factors to differ across countries, while the impact of long-run factors remains the same. The latter assumption is in line with theoretical predictions and our methodology allows testing whether it holds in practice.[2] Second, we allow sovereign borrowing costs to deviate from their long-run equilibrium levels and evaluate the extent of this deviation during the global financial crisis in euro area countries. In addition, we assess the speed of adjustment of sovereign bond yields to their long-run equilibrium level.

Using annual data for a sample of 22 advanced economies over the period 1980–2010, we find evidence supporting the long-run relationship between sovereign borrowing costs and their main fundamental determinants: the government debt-to-GDP ratio and potential growth. We provide statistical support to the hypothesis that this relationship is common to all advanced economies. In the long run, government bond yields increase by about 2 basis points in response to a 1 percentage point increase in the government debt-to-GDP ratio and by about 45 basis points in response to a 1 percentage point increase in the potential growth rate. At any period of time, sovereign bond yields may deviate from the level determined by the long-run fundamentals, but about half of the deviation adjusts in one year. In the short run, changes in government bond yields respond to changes in the debt-to-GDP ratio, the money market rate (monetary policy effect), and inflation (nominal shocks), while the impact of changes in the growth rate and the primary balance ratio is weaker. One caveat with interpreting the short-run results is that they are obtained from a very parsimonious model that does not account for some factors that likely contributed to the temporary deviation of sovereign borrowing costs from their long-run equilibrium level in the aftermath of the crisis but are difficult to quantify (for instance, policy uncertainty).

The rest of the paper is structured as follows. Section 2 reviews the existing literature, with a particular focus on government debt as a determinant of sovereign bond yields. Section 3 describes the new empirical technique employed in the analysis and the data. Section 4 presents and discusses the empirical findings. The last section concludes.

## 2. Determinants of sovereign bond yields: review of existing studies

### 2.1. Theoretical considerations

Economic theory suggests that in the *long run*, real government bond yields depend on two main determinants: potential output growth and government debt.

The link between *potential output growth* and real bond yield can be illustrated using Euler's equation from the consumer's utility maximization problem. In a Ramsey model of economic growth with a representative household's preferences described by the CES utility function and a production

[1] The only paper we are aware of that uses a similar methodology is Conway and Orr (2002). However, their sample includes only a limited number of advanced economies (seven in total) and does not cover the global financial crisis period.

[2] The fixed effects methodology employed in previous studies imposes the relationship between sovereign bond yields and their fundamentals (the slope coefficients) to be the same across countries, without testing the validity of this assumption.

process described by the Cobb–Douglas function, the deterministic steady state of the real bond yield is determined by (Laubach, 2009)[3]:

$$r = \sigma g + \theta \tag{1}$$

where $g$ denotes real consumption growth, $\sigma$ is the inverse of the intertemporal elasticity of substitution, and $\theta$ is the household's rate of time preference. In a closed economy, consumption and output growth rates can be considered equivalents in the steady state, implying that the real bond yield is positively related to long-run output growth. In an open economy, (1) would also include a foreign risk-free rate ($r^*$) and exchange rate change on the right-hand side in order for the uncovered interest parity condition to hold (see Smith and Wickens, 2002, for the derivations). The positive relationship between real bond yields and long-run output growth still holds in the latter case.

*Government debt* may affect real bond yields through two key channels. First, fiscal expansion may crowd out private investment (assuming the Ricardian equivalence does not hold), resulting in a lower steady-state capital stock, which in turn would lead to a higher marginal product of capital and consequently a higher real interest rate (Engen and Hubbard, 2004). Second, a higher debt may boost sovereign bond yields through the default risk premium, as implied by existing models of sovereign debt crises which link the default risk to the ratio of debt to the government's income stream (Manasse et al., 2003). Both channels imply a positive long-run association between real bond yields and government debt.

In addition to the long-run factors, in the *short run* real government bond yields may also be affected by changes in the money market rate (monetary policy stance), temporary inflation shocks and changes in fiscal balances, and fluctuations of output growth around its potential level.[4] These factors can result in temporary deviations of real bond yields from their long-run equilibrium level (see below).

### 2.2. Empirical evidence

The empirical literature on determinants of government bond yields can be subdivided into two strands: single-country studies and panel data studies.[5] The advantage of *single-country* studies is that they pay greater attention to issues specific to the particular country under consideration by using corresponding control variables and focusing on relevant sample periods. The disadvantage is the short time series dimension of the data, which makes the statistical inference challenging.[6] In contrast, the advantage of *panel data* studies is that they improve the statistical inference by expanding the cross-sectional dimension of the data. However, their disadvantage is the implicit assumption that bond yields in all countries included in the panel respond to changes in economic fundamentals similarly (homogeneity).[7] Below, we discuss key country-specific and panel data studies on the topic, with a particular focus on their findings with respect to the impact of government debt variables.

[3] To illustrate this point, consider the standard intertemporal maximization condition (Euler's equation) from the household's utility maximization problem: $\partial U_t/\partial C_t = \beta R_t E_t(\partial U_{t+1}/\partial C_{t+1})$, where $U$ is the consumer's utility function, $C$ is consumption, $\beta$ represents the consumer's intertemporal preferences (the discount factor), and $R$ is the interest rate. Assuming that the utility function takes the constant relative risk aversion (CRRA) form, $U_t = C_t^{(1-\sigma)}/(1-\sigma)$, the intertemporal maximization condition can be written as: $R_t = (1/\beta)E_t[(C_{t+1}/C_t)^{-\sigma}]$, where $\sigma$ is the relative risk aversion parameter. Proxying the consumption growth rate by the output growth rate and log-linearizing all variables around their steady state values yields the above expression.

[4] It is important to note that while the potential output growth is expected to have a positive impact on real bond yields in the long run, a short-run positive deviation of output growth from its potential level could reduce borrowing costs, as the temporary increase in the taxing capacity of the country lowers the sovereign risk.

[5] There is also a large group of studies analyzing the determinants of government bond yield spreads. We do not review these papers given that this topic, despite being closely related, is beyond the scope of our study.

[6] The short time series dimension of the data is particularly acute in studies using macroeconomic (especially fiscal) determinants of bond yields, which are typically available only in low frequencies (annual or quarterly).

[7] The fixed effects specification only partially relaxes this assumption by introducing country-specific intercepts, while maintaining the homogeneity of slope coefficients.

#### 2.2.1. Single-country studies

Single-country studies employ time series regression methods to analyze the impact of fundamentals on sovereign borrowing costs. In addition to stock and flow fiscal variables (debt and deficit, respectively),[8] the reduced form equations typically include additional controls, such as short-term interest rates (determined by monetary policy and therefore considered exogenous), inflation, money growth, etc.

These studies mostly focus on the case of the U.S. (Gale and Orzsag, 2002; Brook, 2003, and Haugh et al., 2009, provide a comprehensive literature overview). Most papers employ a static specification (e.g., Elmendorf, 1993; Cebula, 2000), but some also explore the dynamic aspects of the impact of fiscal variables. For instance, Plosser (1987) and Evans (1987) use a VAR approach to isolate the impact on bond yields of the unexpected component of changes in fiscal variables. Interestingly, in contrast to studies employing static specification, the VAR studies do not find that unexpected changes in fiscal variables have a significant impact on government bond yields.

Several studies explicitly recognize that in the presence of forward-looking market participants, sovereign borrowing costs depend on expected rather than current fiscal variables. Among these studies, Wachtel and Young (1987), Thorbecke (1993) and Elmendorf (1996) analyze the relation between news on the budgets printed in the press or new data announcements by budgetary institutions and the day-to-day change in government bond rates. More recently, Engen and Hubbard (2004) and Laubach (2009) use predicted values of U.S. fiscal variables from the Congressional Budget Office (CBO) as determinants of sovereign borrowing costs. The authors argue that using predicted values helps disentangling the effect of fiscal policy from other factors influenced by the business cycle. Their results suggest that a 1 percentage point increase in the expected government debt-to-GDP ratio raises real long-term government bond yields by about 2–5 basis points.

Few single-country studies analyze countries other than the U.S. For example, Chinn and Frankel (2005) study the cases of five European countries (France, Germany, Italy, Spain, and the U.K.) and the U.S. by running separate regressions for each country. Using data for the 1988–2004 period, they find that the impact of a 1 percentage point increase in the government debt-to-GDP ratio on real long-term government bond yields varies slightly across countries. The impact is stronger in European countries, ranging from 5–8 basis points (Germany) to 10–16 basis points (France, Italy, the U.K., and Spain), compared to the U.S., where the impact is 5 basis points when the 1988–2002 sample is used (the impact is obscured when the sample is extended to 2004). However, the individual country regressions conducted in this study should be taken with caution given the very limited sample size (17 observations). Another relevant single-country study is that by Lindé (2001), who analyzes the case of Sweden using data for the period 1982–1996. Linde's results support the theoretical prediction that higher budget deficits induce higher sovereign borrowing costs.

#### 2.2.2. Panel data studies

The panel data studies typically employ the FE specification, where fiscal variables (most notably, the debt-to-GDP ratio) are introduced along with other control variables (including GDP growth) as long-run determinants of sovereign borrowing costs. Most of these studies do not distinguish between long-run and short-run effects of sovereign bond yield determinants and focus only on the long-run association between bond yields and fundamental factors.

Kinoshita (2006) develops a theoretical model linking government bond yields to government debt and tests its predictions using a panel of 19 advanced economies. The results suggest that a 1 percentage point increase in the government debt-to-GDP ratio raises the real long-term government bond yields by about 2–5 basis points. This impact is comparable to the 3–5 basis points effect found in Laubach (2009) and Engen and Hubbard (2004) for the U.S.

Hauner and Kumar (2009) explicitly focus on the impact of the global financial crisis in their attempt to resolve the "conundrum" of low government bond yields and high fiscal imbalances observed in G-7 advanced economies in the aftermath of the crisis. Their results suggest that the

[8] As discussed in Baldacci and Kumar (2010), the coefficients of deficit and debt variables are closely related in the presence of permanent shocks to deficits. More specifically, the impact on the debt ratio of a permanent 1 percentage point increase in the deficit ratio is $(1+g)/g$, where $g$ is the nominal GDP growth rate (in percent).

upward pressures on government bond yields due to the chronic weakening of budgetary positions were more than offset by foreign inflows triggered by "safe-heaven" considerations. However, they warn about the temporary nature of these effects and predict that an upward correction in bond yields is inevitable in the long run.

Ardagna et al. (2007) use a panel of 16 OECD countries over 1960–2002 to investigate the impact of fiscal deficits and debt on long-term government bond yields. They confirm the importance of both stock and flow fiscal variables as determinants of government borrowing costs. They also document nonlinearities in the impact of government debt, with the impact of debt being more pronounced for countries having above average debt levels. More specifically, in their linear specification, a 1 percentage point increase in the debt-to-GDP ratio leads only to a 0.6 basis point increase in long-term government bond yields. By contrast, in the non-linear specification, the effect of a 1 percentage point increase in the debt-to-GDP ratio on the long-term government bond yield varies from a decrease of about 2.4 basis points for the minimum value of the debt-to-GDP ratio in the sample to an increase of about 3.8 basis points for the maximum value of the debt-to-GDP ratio in the sample.

A similar non-linear effect was found in Conway and Orr (2002). Using data from seven OECD economies, the authors find that a 1 percentage point increase in the debt-to-GDP ratio leads to a less than 1 basis point increase in the government bond yield if starting from a (hypothetical) 0 percent debt-to-GDP ratio, and an increase of about 2 basis points if starting from a 100 percent debt-to-GDP ratio.

Faini (2006) studies the case of 10 euro area countries for the period 1979–2002. The author finds that public debt has no significant impact on long-term government bond yields in individual country regressions, but its impact becomes significant for the 10 euro area countries as a whole.[9] In the panel estimations, a 1 percentage point increase in the debt-to-GDP ratio results in an increase of about 3 basis points in long-term government bond yields. Similarly to Ardagna et al. (2007), he finds that borrowing costs of sovereigns with a higher level of debt (above 100 percent of GDP) are more sensitive to changes in the debt-to-GDP ratio than those of countries with a lower level of debt.

Finally, Baldacci and Kumar (2010) use a sample of 31 advanced and emerging economies during the pre-crisis period (1980–2008) and introduce debt-to-GDP ratios into the specification in both linear and quadratic fashion. Their estimations suggest that a 1 percentage point increase in the government debt-to-GDP ratio raises the real long-term government bond yield by about 0.8 basis points in G-20 economies (both advanced and emerging) and by about 1.7 basis points in advanced G-20 economies. They also argue that the precise magnitude of the impact depends on the initial fiscal position, institutional and other structural conditions, and spillovers from global financial markets.

### *2.2.3. Key takeaways*

The main results of the empirical studies can be summarized as follows. First, most studies on advanced economies find empirical support for the theoretical prediction that sovereign debt and other macroeconomic fundamentals have an impact on government bond yields. However, in some cases pooling countries into a panel is instrumental to obtaining statistically significant results. Second, the relationship between government bond yields and economic fundamentals may change over time. For instance, the sensitivity of yields to government debt may increase when government debt reaches an unsustainably high level. In a similar vein, the sensitivity may change in response to policy initiatives that reduce exchange rate risks and provide implicit bailout guarantees (the introduction of the euro in 1999 being the most notable example).[10] Finally, the long-run relationship between bond yields and their macroeconomic and fiscal determinants has weakened during the crisis due to "safe-heaven" capital flows. Such temporary deviations of bond yields from their long-run equilibrium level are likely to be reverted in the future and need to be accounted for properly in

[9] Interestingly, Knot and De Haan (1995) arrive at a similar conclusion using a sample of five European countries.

[10] A separate stream of literature, not reviewed here due to space constraints, provides strong evidence that the response of sovereign bond spreads to changes in macroeconomic and fiscal determinants has substantially weakened in advanced euro area countries following the introduction of the euro in 1999 (see, e.g., Attinasi et al., 2009; Schuknecht et al., 2010; Bernoth et al., 2012; De Grauwe and Ji, 2012).

empirical estimations. More specifically, they should be modeled as short-run factors and should not be confused with long-run determinants of bond yields.

## 3. Empirical methodology and data

### 3.1. Empirical methodology

Motivated by the issues raised in the literature review section, we adopt an empirical methodology which strikes a middle ground between the two approaches (single-country and panel data methods) used in most studies to analyze the determinants of government bond yields in advanced economies. More specifically, we apply the pooled mean group (PMG) estimator of Pesaran et al. (1999), which is a panel data version of the error-correction model.

The empirical specification takes the following form:

$$\Delta r_{it} = \phi_i\left[r_{it-1} - \beta_0 - \beta_1' LR_{it-1} - \beta_2' LR_{it-1} \times D_{EA}\right] + \delta_i' \Delta SR_{it} + \varepsilon_{it}, \tag{2}$$

where the dependent variable is the change in real bond yields ($\Delta r$), the $i$ and $t$ indices denote country and time, and $\varepsilon$ is an i.i.d. error term. The model is parsimonious and only includes two long-run determinants ($LR$) of real bond yields: the potential growth rate and the debt-to-GDP ratio. An interaction term with the EA dummy ($D_{EA}$) is added to account for interest rate convergence within the euro area following the introduction of the common currency (it takes the value of one during the period 1999–2010 for euro area countries). Following the existing literature, up to five short-run determinants ($\Delta SR$) are also included: changes in the debt-to-GDP ratio, changes in the real money market rate (monetary policy effect), changes in inflation (nominal shocks), changes in the primary balance ratio (short-term fiscal policy), and changes in the growth rate (cyclical fluctuations).[11] Table 1 provides the expected signs for each of these determinants:

- Changes in the *debt ratio*. It will take time for the financial market to decipher a transitory from a permanent shock to the debt ratio, and hence real long-term bond yields will be positively impacted in the short run. If the shock turns out to be transitory, long-term bond yields will temporarily deviate up from their long-run equilibrium level and return to that level in the long run at the pace defined by the speed of adjustment coefficient.
- Changes in *inflation*. Similarly, it will take time for the financial market to decipher a transitory from a permanent inflation surprise, and hence real long-term bond yields will be negatively impacted in the short run as inflation enters the equation of real yields with a negative sign.
- Changes in real *short-term rates*. This term measures the influence of monetary policy on long-term bond rates, with the immediate impact of a policy tightening being a rise in long-term bond rates.
- Changes in *output growth*. This term measures the influence of cyclical developments in output growth on long-term bond rates. It is important to note that while the potential output growth is expected to have a positive impact on real bond yields in the long run, a short-run positive change in output growth could reduce borrowing costs as the temporary increase in the taxing capacity of the country lowers the sovereign risk in the short run. Hence, we expect a negative relationship between changes in output growth rates and real long-term bond yields.
- Changes in the *primary balance ratio*. Similarly, this term measures the influence of cyclical fiscal policy developments on long-term bond rates. A short-run positive change in the primary balance ratio could reduce borrowing costs as the temporary improvement in the fiscal balance lowers the sovereign risk in the short run. Hence, we expect a negative relationship between changes in the primary balance ratio and real long-term bond yields.

The PMG specification has several advantages for the purpose of our analysis. First, in contrast to the FE specification (and similar to the cointegration methodology used in some country-specific

[11] The PMG specification fully conforms to the empirical implications of the simple theoretical framework based on the Cobb-Douglas production function outlined in Engen and Hubbard (2004). According to this framework, the *level* of the interest rate is determined by the *level* of government debt, while the *change* in the interest rate is affected by the *change* in government debt (pp. 84–85).

**Table 1**
Description of variables and their sources.

| Variable | Description | Expected sign | Source |
|---|---|---|---|
| Dependent variable | | | |
| Real long-term interest rate | Nominal 10 year benchmark bond yield (daily average) minus inflation divided over one plus inflation[a] | | Datastream |
| Long-run determinants | | | |
| General government debt ratio | Ratio of general government debt to GDP (in percent)[b] | (+) | WEO |
| Potential growth[c] | Real GDP growth filtered of cyclical fluctuations | (+) | WEO |
| Short-run determinants | | | |
| Changes in debt ratio | Ratio of general government debt to GDP (in percent)[b] | (+) | |
| Changes in inflation | CPI inflation | (+) | WEO |
| Changes in real short-term interest rate | Nominal 3 months money market rate (daily average) minus inflation divided over one plus inflation | (+) | Datastream |
| Changes in output growth | Real GDP growth | (−) | WEO |
| Changes in primary balance ratio | Ratio of general government primary balance to GDP | (−) | WEO |

*Note*: The sample covers the following advanced economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland, the U.K., and the U.S.

[a] This is Fisher's formula, where "ex post" inflation is calculated using the GDP deflator. Specifically, the real interest rate for period t is measured as the difference between the annual nominal interest rate for a 10-year government bond at $t$ and inflation in period $t$ divided over one plus inflation in period $t$, where inflation in period t is measured as the percentage growth of the GDP deflator between $t-1$ and $t$. We use the GDP deflator rather than CPI because it is the price of goods being produced, which is the more relevant measure from the investment point of view. The underlying assumption behind the "ex post" measure of real rates is that economic agents have rational expectations and the expected value of inflation in period $t$ based on information in period $t-1$ is equal to the realized inflation. In addition, the advantage of the "ex post" measure of the real rate is that it shows the realized annual real return from investing in 10-year government bonds. The same "ex post" concept is applied for calculating the real short-term rate. Unfortunately, survey based expectations of inflation (e.g., Consensus Forecast, EIU, Blue Chip, etc.) are not available for the 80–90s and do not cover all countries in our sample.

[b] Exceptions are Australia, Canada, Japan, and New Zealand, for which the net debt-to-GDP ratio is used.

[c] Potential growth estimates are taken from the IMF's World Economic Outlook database. When measuring potential output, each country desk at the IMF chooses the method that fits the country situation best. The country-specific approach is justified given the heterogeneous countries in the sample with differences with regards to the coverage and the quality of economic data. Most of the time, however, the IMF approach is based on a production function method, but with underlying assumptions that vary across countries (see De Masi, 1997).

studies), the PMG estimator allows differentiating between long-run ($LR$) and short-run determinants of bond yields ($SR$). Second, similar to the FE estimator, the PMG estimator pools coefficients of long-run factors ($\beta$) to improve the statistical inference and comply with theoretical predictions (which are general and should not vary from country to country). However, unlike the FE estimator, it is flexible enough to allow country-specific variations in short-run coefficients ($\delta_i$). This in turn allows a differentiated response to changes in short-term factors (like monetary policy) depending on country-specific characteristics. Finally, the PMG specification can be tested against a more flexible mean-group (MG) estimator that allows for both long-run and short-run coefficients to vary across countries using the Hausman test.[12] If the PMG poolability restrictions are not rejected, then this would imply statistical support to the long-run coefficient homogeneity assumption imposed by the FE estimator.

[12] To illustrate the intuition behind this test, recall that the PMG estimator constrains the long-run slope coefficients to be equal across all panels. This is in contrast to the MG estimator, which does not impose the poolability constraints on the slopes. The pooling across countries yields efficient and consistent estimates when the restrictions are true. However, if the slope homogeneity assumption is rejected by the data, the PMG estimates become inconsistent, while the MG estimates are consistent in either case. The Hausman test provides the statistical evaluation of the difference across these two models under the null hypothesis that the poolability restrictions imposed by the PMG are valid.

**Table 2**
Descriptive statistics.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Real long-term interest rate | 441 | 3.37 | 2.22 | −4.06 | 10.98 |
| General government debt ratio | 441 | 57.63 | 28.59 | −7.23 | 142.76 |
| Inflation | 441 | 2.37 | 1.60 | −1.71 | 12.41 |
| Real short-term interest rate | 441 | 2.35 | 2.45 | −3.52 | 14.42 |
| Potential growth | 441 | 2.54 | 1.42 | −2.33 | 10.62 |
| Primary balance ratio | 441 | −5.28 | 5.20 | −35.16 | 4.16 |
| Output growth | 441 | 2.37 | 2.55 | −8.23 | 10.92 |

### 3.2. Data

The sample consists of annual data on sovereign bond yields and their fundamental determinants for the period 1980–2010 for 22 advanced economies. We use 10-year benchmark government bond yields as a measure of sovereign borrowing costs from daily data on secondary market bond yields available in Datastream. Annual averages were calculated for each country. Data on fiscal and macroeconomic variables was obtained from the IMF's World Economic Outlook Database. Table 1 describes all variables and their sources. Descriptive statistics are shown in Table 2.

Figs. 1 and 2 show the dynamics of real sovereign bond yields and debt-to-GDP ratios in the euro area countries included in our sample. It is interesting to observe that the convergence of real yields[13] following the introduction of the euro in 1999 and until the eruption of the crisis in 2009 was not consistent with the persistently wide dispersion of the main underlying fundamental—the debt-to-GDP ratio—which has not decreased after 1999. This suggests that markets did not fully account for differences in fundamentals when pricing sovereign risk in the euro area countries during this period, which calls for a special treatment in the empirical analysis.

Before turning to the estimations, we apply panel unit root tests on real bond yields, debt-to-GDP ratios, and potential growth rate variables. We use five unit root tests: Im-Pesaran-Shin, Fischer, Levin-Lin-Chu, Breitung, and Hadri. The first four tests are based on the null of unit root and different alternative hypotheses, while the last test is based on the null of stationarity. The latter three tests require a balanced panel of variables and were applied to a shorter version of the dataset. As shown in Table 3, all tests support the unit root hypothesis for the debt-to-GDP ratio. The results are mixed for real bond yields and potential growth rates: two of the tests support the unit root hypothesis for the former, and three support the unit root hypothesis for the latter. The Breitung and Hadri tests support the unit root hypothesis for all three variables, justifying the use of the panel cointegration model.

## 4. Estimation results

### 4.1. Baseline specification

Table 4 shows the estimation results for the baseline specification (2), including the coefficients for the debt-to-GDP ratio and potential growth variables where a euro area dummy is added, as mentioned above. Column (1) shows the results of the full model, column (2) shows the results of the restricted model that excludes insignificant coefficients from the full specification, and column (3) shows the results of the restricted model augmented by the inclusion of the euro area dummy variable among the short-run determinants. The results can be summarized as follows. First, in line with the economic rationale, the long-run coefficient of the debt-to-GDP ratio is positive and significant, suggesting that real bond yields go up by about 2 basis points in response to a 1 percentage point increase in the debt-to-GDP ratio. This estimate is in the lower range of the 2–7 basis point estimates found in previous papers (Baldacci and Kumar, 2010). Similarly, the positive and significant coefficient of the potential growth variable suggests that faster growing countries pay higher interest rates: a 1 percentage point higher potential growth leads to a 45 basis points average increase in real bond yields.

[13] The convergence is even more pronounced when considering nominal yields (see De Grauwe and Ji, 2012).

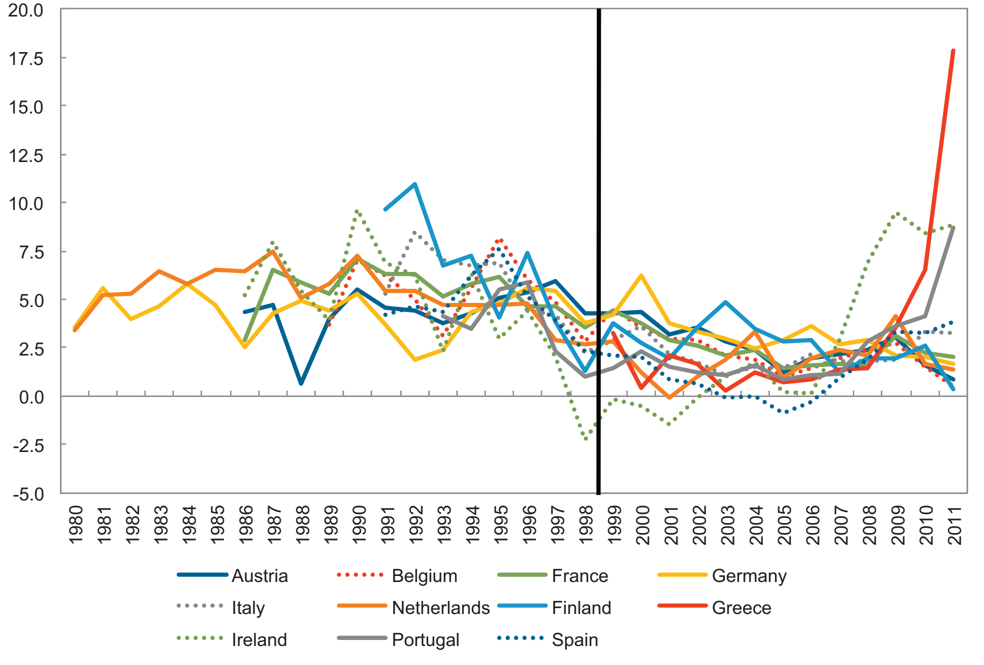


**Fig. 1.** Selected euro area economies: real 10-year sovereign bond yields (in percent).

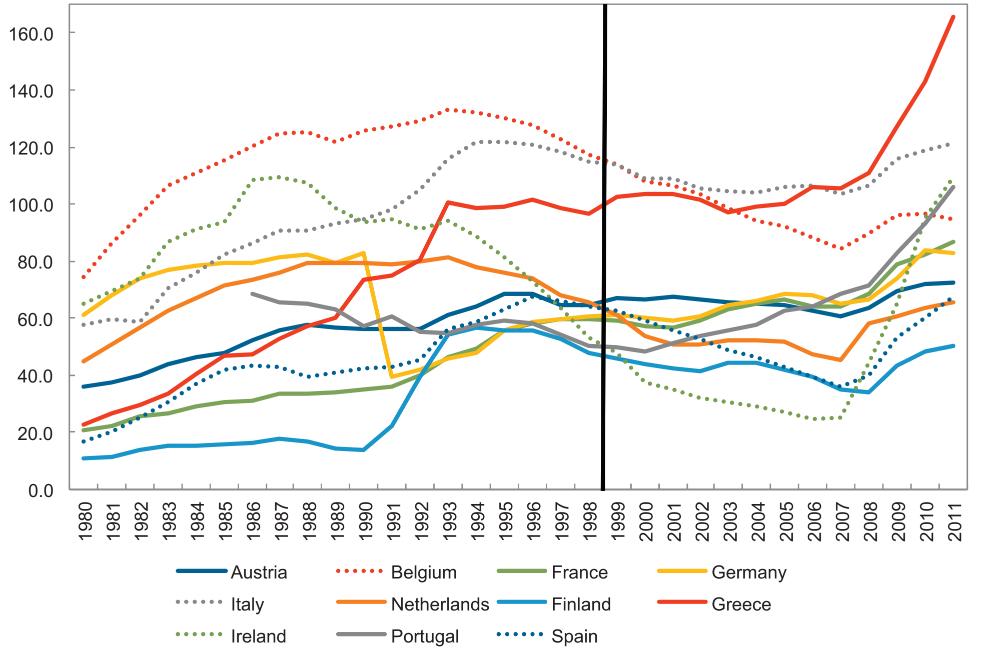


**Fig. 2.** Selected euro area economies: debt-to-GDP ratio (in percent).

**Table 3**
Panel unit root tests.

| Test | Null hypothesis | Alternative hypothesis | Real interest rate | *p*-Value debt ratio | Potential growth |
|---|---|---|---|---|---|
| Im-Pesaran-Shin | All panels contain unit roots | Some panels are stationary | 0.000 | 0.949 | 0.000 |
| Fischer | All panels contain unit roots | At least one panel is stationary | 0.015 | 0.528 | 0.000 |
| Levin-Lin-Chu | All panels contain unit roots | All panels are stationary | 0.007 | 0.263 | 0.105 |
| Breitung | All panels contain unit roots | All panels are stationary | 0.431 | 0.115 | 0.086 |
| Hadri | All panels are stationary | Some panels contain unit roots | 0.000 | 0.000 | 0.000 |

*Note*: The panels include 22 advanced economies. The overall sample covers the 1980–2011 period. Some of the tests require a balanced panel and were therefore applied to a balanced version of the dataset.

Second, the relationship between bond yields and their long-run determinants (debt-to-GDP ratio and potential growth) has weakened substantially in euro area countries following the introduction of the euro. The average coefficient falls to 0.005 for the debt-to-GDP ratio and -0.05 for the potential growth rate when the euro area dummy is added. This finding is in line with recent euro area studies (e.g., De Grauwe and Ji, 2012), which show that markets underestimated the impact of fundamentals when pricing sovereign bond yields in euro area countries in the period following the introduction of the euro and up to the eruption of the crisis.

Third, the speed of adjustment coefficient is negative and significant, supporting the cointegration hypothesis. The average coefficient of −0.45 suggests that almost half of the deviation of real bond yields from their long-run equilibrium level adjusts during one year.

Lastly, most of the short-run variables have significant coefficients and expected signs. The exceptions are the changes in the real growth rate and the primary balance ratio. As expected, short-run changes in real bond yields are affected positively by changes in the debt-to-GDP ratio and short-term interest rates (monetary policy effect) and negatively by changes in inflation. The latter finding can be interpreted as a surprise effect, as short-run changes in inflation result in a temporary decline of real bond yields.

In terms of the model specification, the standard errors of residuals are quite sizeable, ranging between 1.52 and 1.58, but smaller than the standard deviation of real rates in the total sample (2.22). In addition, the Hausman test does not reject the validity of the PMG estimator, suggesting that the association between real bond yields and their long-run determinants is the same across all advanced economies.

### *4.2. Robustness checks*

Table 5 shows the results of several robustness checks that we performed to ensure the results are not affected by different sample coverage. First, we exclude three EU/IMF program countries from the sample: Greece, Ireland, and Portugal. The intuition behind this exclusion is that these countries were cut off from the markets following the launch of their programs. The estimation results reported in column 1 suggest that the main conclusions remain unchanged when the program countries are dropped from the sample.

Second, we augment the long-run equilibrium part of the equation by adding a U.S. dummy variable. This variable is expected to capture the reserve currency status of the U.S. dollar and its potential impact on U.S. borrowing costs. The same exercise is repeated for Japan. The estimation results reported in columns 2 and 3 suggest that long-run equilibrium real bond yields in these countries were not significantly affected by their reserve currency status. The impact of other variables remains qualitatively unchanged.

Third, we analyze the impact of the global financial crisis by restricting the sample to the pre-crisis period ending in 2007. The estimation results reported in column 4 suggest that the magnitude of long-run coefficients on the debt-to-GDP ratio and potential growth was somewhat smaller before the crisis. This highlights the fact that markets started paying closer attention to the fundamental determinants of real bond yields in the aftermath of the crisis. The impact of other variables remains

**Table 4**
Baseline regressions.

| | (1) Full model | (2) Restricted model | (3) Adding EA dummy |
|---|---|---|---|
| Long-run coefficients | | | |
| Debt ratio | 0.014** | 0.021*** | 0.025*** |
| | [0.006] | [0.005] | [0.005] |
| Potential growth | 0.649*** | 0.322** | 0.393*** |
| | [0.143] | [0.129] | [0.114] |
| Debt ratio × Dummy_EA (1999–2009) | −0.010** | −0.020*** | −0.016*** |
| | [0.005] | [0.005] | [0.005] |
| Potential growth × Dummy_EA (1999–2009) | −0.763*** | −0.395*** | −0.359** |
| | [0.128] | [0.128] | [0.160] |
| Constant | 1.625*** | 2.013*** | 1.675*** |
| | [0.545] | [0.477] | [0.453] |
| Speed of adjustment | −0.390*** | −0.426*** | −0.526*** |
| | [0.036] | [0.034] | [0.052] |
| Short-run coefficients | | | |
| Δ Debt ratio | 0.091*** | 0.081*** | 0.092*** |
| | [0.027] | [0.017] | [0.020] |
| Δ Inflation | −0.141** | −0.159* | −0.160** |
| | [0.070] | [0.086] | [0.080] |
| Δ Short-term real rate | 0.151*** | 0.135*** | 0.124*** |
| | [0.044] | [0.043] | [0.040] |
| Dummy_EA (1999–2009) | | | −0.248* |
| | | | [0.134] |
| Δ Output growth | 0.007 | | |
| | [0.044] | | |
| Δ Primary balance | −0.007 | | |
| | [0.056] | | |
| Obs. | 441 | 441 | 441 |
| Countries | 22 | 22 | 22 |
| AIC | 1166.501 | 1268.079 | 1247.37 |
| BIC | 1211.481 | 1304.881 | 1288.26 |
| Hausman $p$-value | 0.893 | 0.902 | 0.644 |
| St. Dev. of residuals | 1.52 | 1.53 | 1.58 |

*Note*: Estimations are performed using the PMG estimator of Pesaran et al. (1999). The reported short-run coefficients and the speed of adjustment are simple averages of country-specific coefficients. Robust standard errors are in parentheses.
* Significance at 10 percent confidence level.
** Significance at 5 percent confidence level.
*** Significance at 1 percent confidence level.

qualitatively unchanged with the exception of the short-run coefficient on changes in inflation, which turns insignificant.

Finally, we augment the short-run dynamics part of the equation by adding a measure of global economic uncertainty. Following previous studies, we use the VIX index (a measure of the volatility implied in the pricing of options on US stocks compiled by the Chicago Board Options Exchange) as a proxy of global economic uncertainty. As argued in Gonzalez-Rosada and Levy-Yeyati, 2008, global economic uncertainty is increasingly seen as a key determinant of sovereign borrowing costs as it reflects changes in global risk appetite by investors. The estimation results reported in column 5 support this notion and suggest that positive changes in global economic uncertainty increase sovereign borrowing costs in the short run. The impact of other variables remains qualitatively unchanged.

Overall, the robustness checks confirm that the main results on the long-run and short-run determinants of government bond yields remain intact to different samples and additional controls.

**Table 5**
Robustness checks.

| | (1) Excluding program countries | (2) Adding US dummy | (3) Adding JP dummy | (4) Using pre-crisis sample | (5) Adding economic uncertainty |
|---|---|---|---|---|---|
| Long-run coefficients | | | | | |
| Debt ratio | 0.021*** | 0.021*** | 0.016** | 0.012** | 0.019*** |
| | [0.005] | [0.005] | [0.007] | [0.006] | [0.005] |
| Potential growth | 0.527*** | 0.328** | 0.591*** | 0.303** | 0.294** |
| | [0.136] | [0.135] | [0.146] | [0.144] | [0.134] |
| Debt ratio × Dummy_EA (1999–2009) | −0.016*** | −0.020*** | −0.016*** | −0.024*** | −0.018*** |
| | [0.005] | [0.005] | [0.006] | [0.006] | [0.005] |
| Potential growth × Dummy_EA (1999–2009) | −0.487*** | −0.395*** | −0.434*** | −0.381** | −0.470*** |
| | [0.133] | [0.128] | [0.154] | [0.158] | [0.139] |
| Constant | 1.511*** | 2.003*** | 1.483*** | 2.566*** | 2.180*** |
| | [0.498] | [0.484] | [0.521] | [0.405] | [0.486] |
| Dummy_US | | −0.024 | | | |
| | | [0.272] | | | |
| Dummy_Japan | | | 0.798 | | |
| | | | [0.586] | | |
| Speed of adjustment | −0.425*** | −0.426*** | −0.394*** | −0.406*** | −0.406*** |
| | [0.040] | [0.034] | [0.035] | [0.062] | [0.034] |
| Short-run coefficients | | | | | |
| Δ Debt ratio | 0.074*** | 0.081*** | 0.082*** | 0.082*** | 0.086*** |
| | [0.018] | [0.017] | [0.017] | [0.020] | [0.018] |
| Δ Inflation | −0.218** | −0.158* | −0.174** | −0.127 | −0.187** |
| | [0.091] | [0.086] | [0.086] | [0.091] | [0.089] |
| Δ Short-term real rate | 0.121*** | 0.136*** | 0.127*** | 0.153*** | 0.158*** |
| | [0.047] | [0.043] | [0.045] | [0.045] | [0.042] |
| Δ Volatility index (VIX) | | | | | 0.039*** |
| | | | | | [0.012] |
| Obs. | 390 | 441 | 441 | 388 | 439 |
| Countries | 19 | 22 | 22 | 22 | 22 |
| AIC | 1086.85 | 1270.07 | 1275.56 | 1035.02 | 1230.84 |
| BIC | 1122.54 | 1310.96 | 1316.45 | 1070.67 | 1271.69 |
| Hausman $p$-value | 0.93 | 0.94 | 1.00 | 0.47 | 0.81 |
| St. Dev. of residuals | 1.52 | 1.53 | 1.51 | 1.52 | 1.67 |

*Note*: Estimations are performed using the PMG estimator of Pesaran et al. (1999). The reported short-run coefficients and the speed of adjustment are simple averages of country-specific coefficients. Robust standard errors are in parentheses.
* Significance at 10 percent confidence level.
** Significance at 5 percent confidence level.
*** Significance at 1 percent confidence level.

### 4.3. Did euro area sovereign borrowing costs deviate from their "fair value"?

The above discussion suggests that government bond yields can temporarily deviate from their long-run equilibrium levels. This deviation can occur as a result of changes in market perception during periods of financial stress, when investors' decisions can be largely explained by "herding behavior" amidst increased risk aversion rather than economic fundamentals.

Did euro area sovereign borrowing costs deviate from their "fair value" in the aftermath of the crisis? To answer this question, we compare the actual spread between real bond yields in Germany and those in other euro area countries during the first half of 2012 and the spread calculated using the predicted yields from all seven models shown in Tables 4 and 5 to account for the model prediction uncertainty.

As shown in Fig. 3, the model suggests that in some European periphery countries, bond yield spreads (relative to Germany) exceeded their equilibrium value determined by long-run and

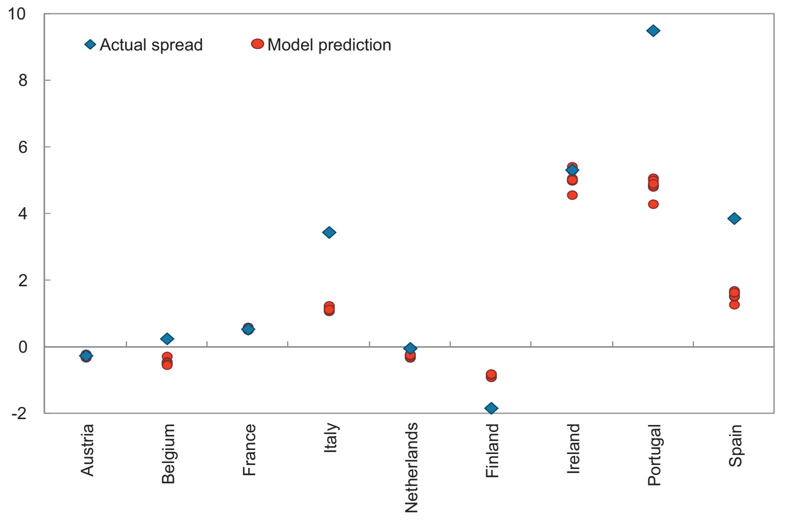


**Fig. 3.** Selected euro area economies: comparison of predicted and actual long-run real bond spreads vis-à-vis Germany (first half of 2012). *Note*: reported are prediction results from seven models shown in Tables 4 and 5. All spreads are calculated using real bond yields.

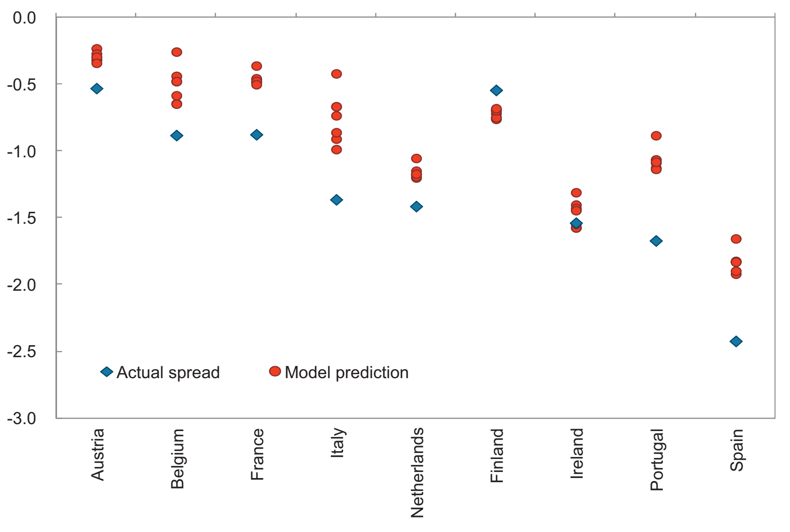


**Fig. 4.** Selected euro area economies: comparison of predicted and actual long-run real bond spreads vis-à-vis Germany (1999–2009, average). *Note*: reported are prediction results from seven models shown in Tables 4 and 5. All spreads are calculated using real bond yields.

short-run fundamentals in the first half of 2012. The opposite picture emerges when considering the case of several core euro area countries (e.g., Finland), where "safe-haven" effects result in spreads undershooting their equilibrium value. It is interesting to note the contrasting results obtained for the pre-crisis period (1999–2009), during which the spreads in European periphery countries were lower than the level justified by fundamentals (see Fig. 4). A similar result on downward deviation during the 1999–2009 period and upward deviation in the aftermath of the crisis was also obtained in other recent studies of euro area countries (e.g., De Grauwe and Ji, 2012; Di Cesare et al., 2012). All in all, the model suggests that in some members of the euro area, current sovereign borrowing costs deviate from the equilibrium level defined by macroeconomic fundamentals. However, when interpreting these results one should bear in mind that they are obtained form a very parsimonious model that does not account for some factors that likely contributed to the temporary deviation of sovereign borrowing costs from their long-run equilibrium level in the aftermath of the crisis (for instance, policy uncertainty, liquidity and default risks – see Krishnamurthy and Vissing-Jorgensen, 1995; Beirne and Fratzscher, 2013; Groba et al., 2013).

## 5. Conclusions

This paper applies panel cointegration techniques to analyze long-run and short-run determinants of government bond yields in 22 advanced economies during 1980–2010. The employed methodology has several advantages over the techniques used in previous studies: (i) it allows explicitly differentiating between long-run and short-run determinants of bond yields; (ii) it pools long-run coefficients to improve efficiency and comply with theoretical predictions while maintaining flexibility in allowing for country-specific variation of short-run coefficients; and (iii) it allows testing for coefficient poolability.

The estimations suggest that in the long run, government bond yields increase by about 2 basis points in response to a 1 percentage point increase in the government debt-to-GDP ratio and by about 45 basis points in response to a 1 percentage point increase in the potential growth rate. In the short run, changes in real bond yields deviate from their long-run equilibrium in response to changes in the debt-to-GDP ratio (positive effect), real money market rates (positive effect), and inflation (negative effect). The impact of changes in the growth rate (negative effect) and the primary balance ratio (negative effect) is weaker. On average, about half of the deviation from the long-run equilibrium is corrected within one year.

When applied to the current period, the model suggests that in some European periphery countries, bond yield spreads (relative to Germany) in the first half of 2012 exceeded the equilibrium value associated with long-run and short-run fundamentals. The opposite picture emerges in the case of several core euro area countries (for example Finland), where “safe-haven” effects result in spreads undershooting their equilibrium value. All in all, the model suggests that, in some members of the euro area, current sovereign borrowing costs deviate from the equilibrium level defined by macroeconomic fundamentals.

Nevertheless, when interpreting these results, one should keep in mind that the analysis does not account for some factors that likely contributed to the temporary deviation of sovereign borrowing costs from their long-run equilibrium level in the aftermath of the crisis. These include, for example, uncertainties related to the feedback effects between banks and sovereigns and the contingent liabilities of the public sector. In addition, frequent reassessment of sovereign borrowing costs by the market should not be interpreted as evidence against the effectiveness of fiscal adjustment to reduce borrowing costs. A steady pace of fiscal adjustment remains imperative for anchoring lower borrowing costs in the long run, while short-run departures of borrowing costs from the long-run equilibrium should be addressed through complementary policies aimed at reducing financial stress and market uncertainty.

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