Working Paper No. 889

The Dynamics of Government Bond Yields in the Eurozone

by

Tanweer Akram*
Thrivent Financial

Anupam Das
Mount Royal University

May 2017

* Tanweer Akram is director of global public policy and economics at Thrivent Financial. Anupam Das is associate professor in the department of economics, justice, and policy studies at Mount Royal University, Alberta, Canada. Disclaimer: The authors' institutional affiliations are provided solely for identification purposes. The views expressed are not necessarily those of Thrivent Financial, Thrivent Asset Management, or any affiliates. This is for information purposes only and should not be construed as an offer to buy or sell any investment product or service. Disclosure: Akram's employer, Thrivent Financial, invests in a wide range of securities. Asset management services are provided by Thrivent Asset Management, LLC, a wholly owned subsidiary of Thrivent Financial, the marketing name for Thrivent Financial for Lutherans, Appleton, Wisconsin. Securities and investment advisory services are offered through Thrivent Investment Management, Inc., a FINRA and SIPC member and a wholly owned subsidiary of Thrivent Financial. Note: The dataset used in the empirical part of this paper is available upon request to bona fide researchers for the replication and verification of the results.

Levy Economics Institute
P.O. Box 5000
Annandale-on-Hudson, NY 12504-5000
http://www.levyinstitute.org

ISSN 1547-366X

ABSTRACT

This paper investigates the determinants of nominal yields of government bonds in the eurozone. The pooled mean group (PMG) technique of cointegration is applied on both monthly and quarterly datasets to examine the major drivers of nominal yields of long-term government bonds in a set of 11 eurozone countries. Furthermore, autoregressive distributive lag (ARDL) methods are used to address the same question for individual countries. The results show that short-term interest rates are the most important determinants of long-term government bonds' nominal yields, which supports Keynes's (1930) view that short-term interest rates and other monetary policy measures have a decisive influence on long-term interest rates on government bonds.

Keywords: Government Bond Yields; Interest Rates; Monetary Policy; Eurozone

JEL Classifications: E43, E50, E60, G10, G12, O16

I: INTRODUCTION

The turbulence in government bond markets in the eurozone countries has been a key feature of the financial, economic, and political crisis that has plagued the region. In late 2010, interest rates on long-term government bonds for a number of countries of the eurozone—specifically Portugal, Ireland, Italy, Greece, and Spain (collectively labelled as the PIIGS)—began to rise sharply (see figure 1). Investors had become concerned about the debt sustainability of these countries due to the elevated ratio of government debt to nominal GDP (see figure 2), large ratios of net government borrowing (fiscal deficits) to nominal GDP, bursting of asset/housing bubbles, severe economic slowdown, elevated risks of default, and/or increased political risks, including the prospect of the exit of these countries from the eurozone.

Figure 1: The Evolution of Government Bond Yields in Selected Eurozone Member Countries

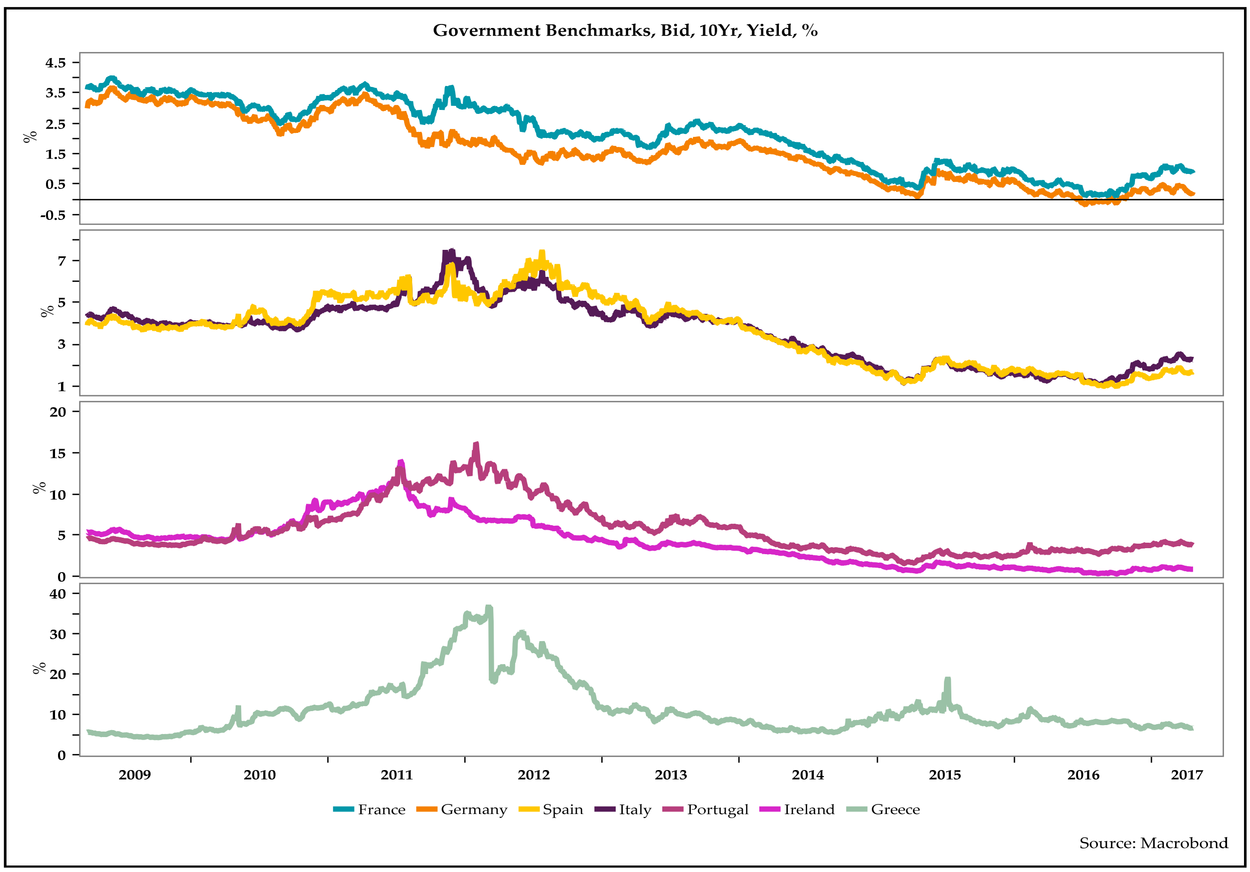
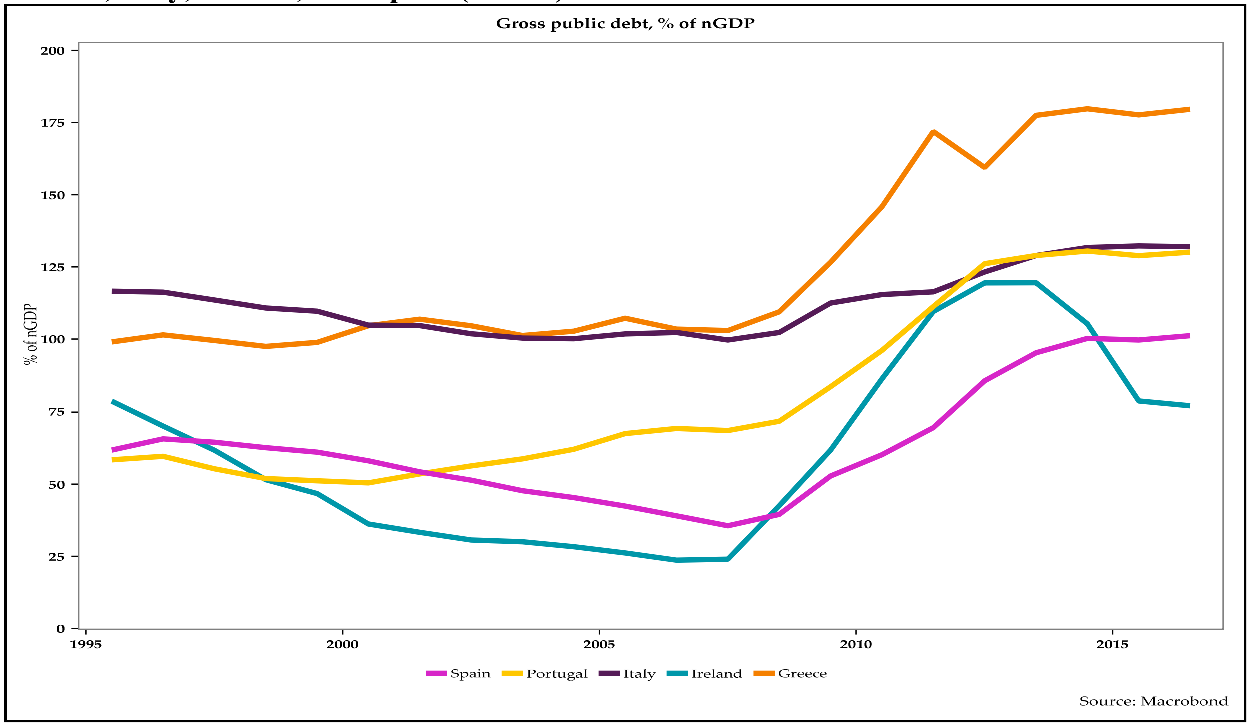


Figure 2: The Evolution of Government Debt as Share of Nominal GDP in Portugal, Ireland, Italy, Greece, and Spain (PIIGS)



These concerns remained in the minds of bond investors and traders until the European Central Bank (ECB), the eurozone's central bank, made clear that it was committed to providing liquidity to the financial system, keeping government bond yields of eurozone countries contained, taking appropriate steps to ensure the stability of the payment and financial systems, and maintaining the common currency. Since mid-2013, interest rates on government bonds have declined for most eurozone countries, particularly Italy and Spain. Nevertheless, interest rates of Greek government bonds remained high as of April 2017, as investors' concerns about the country's debt sustainability and the effects of the troika-imposed economic austerity program have lingered. Meanwhile, the ECB has cut its deposit rate to below zero. The eurozone has been mired in low inflation and deflationary threats. As a result, yields on government bonds of various tenors in several eurozone countries—including Belgium, Germany, Finland, France, Austria, and the Netherlands—have exhibited low or even negative yields since 2016.

While turbulence in the government bond markets has subsided notably since 2012 when Mario Draghi (2012), the president of the ECB, announced that he was committed to do "whatever it takes" to ensure the euro would survive, the financial, economic, and political crisis is far from over. Understanding the dynamics of government bond yields in the eurozone is an important issue because it can provide a useful perspective on the causes of the ongoing crisis there. Such analysis can also be the basis for formulating, implementing, and evaluating appropriate financial, economic, and structural policies that may mitigate the crisis.

This paper is structured in five sections. Section II provides the theoretical overview and places the research issue of the current paper in the context of the existing empirical literature on government bond yields. Section III describes the data and the empirical methodology. Section IV reports the empirical findings from panel and time-series estimates. Section V concludes and identifies issues for further research.

II: THEORETICAL OVERVIEW AND A BRIEF REVIEW OF THE EMPIRICAL LITERATURE ON GOVERNMENT BOND YIELDS

The conventional view is that elevated government debt, fiscal deficits, and government spending crowds out gross domestic private fixed investment and raises long-term interest rates on government bonds. A number of researchers have argued that higher government debt ratios and fiscal deficit ratios lead to higher government bond yields because investors become doubtful of a country's debt sustainability. Baldacci and Kumar (2010), Gruber and Kamin (2012), Lam and Tokuoka (2013), Poghosyan (2014), and Tokuoka (2012) support the view that countries with higher indebtedness and fiscal deficits tend to exhibit higher government bond yields. Reinhart and Rogoff (2009) hold that high government debts and deficits lead to not just higher bond yields, but also slower economic growth, higher inflation, and an increase in the likelihood of debt default. The conventional view is that government financial variables are the most important driver of government bond yields. In particular, elevated and rising government indebtedness can lead to higher government bond yields and a disruptive default on government debt.

In contrast to the conventional wisdom, the Keynesian view is that the central bank's policy rates and monetary policy tools are the key drivers of government bond yields (Keynes 1930 and 2007

[1936]). Keynes's views are based on: (1) stylized facts about the behavior of government bond yields, in particular Riefler's (1930) statistical analysis of long-term government bond yields in the US; and (2) his observations of agents in the financial markets who tend to be mostly influenced by recent developments and the near-term outlook, as well as his analysis of the operations of central banks in advanced capitalist economies (Kregel 2011). Modern money theorists, such as Wray (2003 [1998] and 2012), Fulwiller (2016), and Mitchell (2015), as well as several New Keynesian macroeconomists, such as Sims (2013) and Woodford (2001), hold that governments that issue their own currency and retain monetary sovereignty have the operational ability to service government debt issued in that currency. In the Keynesian view, the central bank's actions have a decisive influence on the long-term interest rates of government bonds because the central bank sets the policy rate. The policy rate exerts strong influence over the level and direction of short-term interest rates. Short-term interest rates in turn are the most important driver of the long-term interest rates, even though other variables—such as the pace of inflation and economic activity—may also influence long-term interest rates.

The Keynesian approach to understanding the drivers of government bond yields has been formally modelled and these models have been empirically tested. Akram (2014), Akram and Das (2014a, 2014b, 2015a, 2015b, and 2017), and Akram and Li (2016 and 2017) have constructed models aligned with the Keynesian and modern money theory of long-term interest rates on government bonds. Their empirical findings support the idea that short-term interests have the most important influence on long-term interest rates in several countries: Akram and Li's (2016 and 2017) results show this for the US; Akram (2014) and Akram and Das (2014a and 2014b) uphold that short-term interest rates have driven long-term interest rates in Japan; and Akram and Das (2015a, 2015b, and 2017) corroborate similar results in India, both over the short and long run.

An underlying assumption of the Keynesian and modern money theory approaches to government bond yields is that a country's government exercises monetary sovereignty. A country is regarded as exercising monetary sovereignty if the following conditions are met: (1) it issues its own currencies; (2) the state has the ability to impose taxes on the private sector; and (3) the tax liabilities of the private sector to the state can be met solely by the payments denominated in its own currency. Typically countries with monetary sovereignty have their own central bank that sets the policy rate by targeting the overnight interbank interest rate or setting some other interest rate as its benchmark interest rate for policy purposes; however, the countries of the eurozone cannot exert monetary sovereignty. Mitchell (2015: 337–38) points out that the member countries of the eurozone do not poses monetary sovereignty because “they are forced to use a foreign currency and must issue debt to private bond markets in that foreign currency to fund any fiscal deficits.” Stiglitz (2016: 5) argues that the most important factor in the eurozone’s crisis is “the creation of a single currency, the euro.” He elaborates this point by blaming the eurozone’s crisis on the failure of the eurozone authorities and member states to create institutions suitable for a region that uses a single currency. Sims (2012) states that the creation of the common currency in the eurozone led to “abandoning an effective lender of last resort function and accepting periodic outright government default on debt as part of the new monetary regime.” He calls for fixing the eurozone’s institutional gaps by creating a eurozone authority with taxing power and the ability to issue debt, and purchase and sell the debt of governments of the eurozone countries.

It is unclear to what extent the Keynesian approach to modeling government bond yields can adequately capture the dynamics of government bond yields in the eurozone because of the eurozone member countries’ lack of monetary sovereignty. Hence, it is quite germane to empirically test whether the implications of the Keynesian approach to government bond yields holds in the countries of the eurozone. This is exactly what this paper seeks to do. It does so by using both panel and time-series data from the eurozone countries and applies a number of econometric techniques well suited for panel and time-series models.

III: DATA AND EMPIRICAL METHODOLOGY

3.1 Data

This paper uses monthly and quarterly data to estimate the effects of short-term interest rates and other relevant variables on long-term government bond yields in 11 eurozone countries (listed in the first column of table 1; abbreviations that are used for countries in the names of variables provided later are listed in the second column). While the monthly dataset covers the period from 1997m3 to 2015m9, the quarterly dataset runs from 2000q1 to 2015q2. Selection of the time period in the dataset is constrained by the availability of data on relevant variables.

Table 1: Country List and Abbreviations

Countries	Country abbreviations
Austria	AT
Belgium	BE
Finland	FI
France	FR
Germany	DE
Greece	GR
Ireland	IE
Italy	IT
Netherlands	NL
Portugal	PR
Spain	ES

Table 2 provides the list of variables used in the paper. The first column gives the variable names, the second column describes the data, the third column describes the frequency of the data and indicates whether the data have been converted to a lower frequency, and the final column states the sources of the data. $STIR$ is the short-term interest rates on interbank lending for three months. $INFLYOY$ represents the rate of inflation, which is defined as the year-over-year percentage change in the price of the overall consumer price index (CPI) excluding energy, food, alcohol, and tobacco. Economic activity is proxied by $IPYOY$, which is measured as the year-over-year percentage change in the index of industrial production. $DRATIO$ is defined as the ratio of the government's consolidated gross debt to nominal gross domestic product (GDP); data on the government debt ratio is available only in the quarterly form. $GB2$ and $GB10$ are the nominal yields on long-term government bonds of 2-year and 10-year tenors. In order to examine the effects of the financial crisis, a dummy (labelled as CRISIS) has been created. The crisis period in the monthly dataset is from 2010m12 to 2012m7 and in the quarterly dataset it is from 2010q4 to 2012q3. Data on all variables are collected from Macrobond, which collects and consolidates time-series data from various primary sources.

Table 2: Summary of the Data and the Variables

Variable Labels	Data Description	Frequency	Sources
Short-Term Interest Rates			
AT_STIR	Austria, 3-month Vienna Interbank Offered Rate (VIBOR), %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
BE_STIR	Belgium, 3-month Interbank Rate, %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
FI_STIR	Finland, 3-month Helsinki Interbank Offered Rate (HELIBOR), %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
FR_STIR	France, 3-month Pairs Interbank Offered Rate (PIBOR), %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
DE_STIR	Germany, 3-month Frankfurt Interbank Offered Rate (FIBOR), %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
GR_STIR	Greece, 3-month Interbank Rate, %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
IE_STIR	Ireland, 3-month Dublin Interbank Rate, %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
IT_STIR	Italy, 3-month Interbank Rate on Deposits, %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
NL_STIR	Netherlands, 3-month Amsterdam Inter Bank Offered Rate (AIBOR), %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
PR_STIR	Portugal, 86- to 96-day Interbank Rate, %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
ES_STIR	Spain, 3-month Interbank Rate on Loans, %	Daily; converted to monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
Government Bond Yields			
AT_GB2	Austria, Government Bond, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
BE_GB2	Belgium, Government Bond, Bank of Belgium, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Bank of Belgium, Macrobond
FI_GB2	Finland, Government Bonds, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
FR_GB2	France, Government Bonds, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
DE_GB2	Germany, Government Bonds, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
GR_GB2	Greece, Government Bond, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
IE_GB2	Ireland, Government Bonds, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
IT_GB2	Italy, Government Bonds, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond

Variable Labels	Data Description	Frequency	Sources
NL_GB2	Netherlands, Government Bonds, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
PR_GB2	Portugal, Government Bonds, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
ES_GB2	Spain, Government Bonds, 2 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
AT_GB10	Austria, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
BE_GB10	Belgium, Government Bonds, Bank of Belgium, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
FI_GB10	Finland, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
FR_GB10	France, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
DE_GB10	Germany, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
GR_GB10	Greece, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
IE_GB10	Ireland, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
IT_GB10	Italy, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
NL_GB10	Netherlands, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
PR_GB10	Portugal, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
ES_GB10	Spain, Government Bonds, 10 Year, Yield, %	Daily; converted to monthly; converted to quarterly	Macrobond
Inflation			
AT_INFLYOY	Austria, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
BE_INFLYOY	Belgium, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
FI_INFLYOY	Finland, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
FR_INFLYOY	France, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
DE_INFLYOY	Germany, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond

Variable Labels	Data Description	Frequency	Sources
GR_INFLYOY	Greece, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
IE_INFLYOY	Ireland, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
IT_INFLYOY	Italy, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
NL_INFLYOY	Netherlands, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
PR_INFLYOY	Netherlands, Harmonized Index of Consumer Prices excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
ES_INFLYOY	Spain, Harmonized Index of Consumer Prices, excluding energy, food, alcohol & tobacco, % change y/y	Monthly; converted to quarterly	Eurostat; Macrobond
Economic Activity			
AT_IPYOY	Austria, Industrial Production, seasonally adjusted (SA), % change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
BE_IPYOY	Belgium, Industrial Production, SA,% change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
FI_IPYOY	Finland, Industrial Production SA, % change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
FR_IPYOY	France, Industrial Production, SA, % change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
DE_IPYOY	Germany, Industrial Production, SA, % change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
GR_IPYOY	Greece, Industrial Production, SA,% change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
IE_IPYOY	Ireland, Industrial Production, SA, % change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
IT_IPYOY	Italy, Industrial Production, SA, % change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
NL_IPYOY	Netherlands, Industrial Production, SA, change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
PR_IPYOY	Portugal, Industrial Production, SA, % change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
ES_IPYOY	Spain, Industrial Production, SA, % change y/y	Monthly; converted to quarterly	OECD Main Economic Indicators; Macrobond
Government Finance			
AT_DRATIO	Austria, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
BE_DRATIO	Belgium, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
FI_DRATIO	Finland, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
FR_DRATIO	France, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
DE_DRATIO	Germany, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
GR_DRATIO	Greece, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
IE_DRATIO	Ireland, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
IT_DRATIO	Italy, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond

Variable Labels	Data Description	Frequency	Sources
NL_DRATIO	Netherlands, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
PR_DRATIO	Portugal, Central Government Consolidated Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
ES_DRATIO	Spain, Central Government Consolidation Debt, % of nominal GDP	Quarterly	Eurostat; Macrobond
Dummy Variables			
CRISIS	No financial crisis = 0; Financial crisis =1	Monthly; Quarterly	Authors' calibration

3.2 Methodology

Both panel and country-specific time-series econometric techniques are used to examine the determinants of long-term government bond yields in several eurozone countries. Two sets of equations are used in this paper: one is for the monthly dataset and the other is for the quarterly dataset. The superscript m is used to identify variables in the monthly dataset and the superscript q is used to identify variables in the quarterly dataset.

First, the following behavioral equations are estimated using the monthly dataset:

$$GB2_t^m = a_0 + a_1 STIR_t^m + a_2 INFLYOY_t^m + a_3 IPYOY_t^m + \epsilon_t \qquad \text{(eq. \#1)}$$

$$GB10_t^m = b_0 + b_1 STIR_t^m + b_2 INFLYOY_t^m + b_3 IPYOY_t^m + \varepsilon_t \qquad \text{(eq. \#2)}$$

Second, the quarterly dataset is used to examine the determinants of long-term government bond yields in the eurozone countries. The following behavioral equations are estimated using the quarterly dataset:

$$GB2_t^q = c_0 + c_1 STIR_t^q + c_2 INFLYOY_t^q + c_3 IPYOY_t^q + c_4 DRATIO_t^q + \vartheta_t \qquad \text{(eq. \#3)}$$

$$GB10_t^q = d_0 + d_1 STIR_t^q + d_2 INFLYOY_t^q + d_3 IPYOY_t^q + d_4 DRATIO_t^q + \rho_t \qquad \text{(eq. \#4)}$$

3.2.1 The Methodology for Panel Estimations

The panel unit root tests: Both the monthly and quarterly datasets can be categorized as having a large *T*, that is, long time-series data. For the monthly dataset, *T*=299, and for the quarterly dataset, *T*=63. Nelson and Plosser (1982) argue that macroeconomic variables with a long T can be characterized by the unit root process. To determine the level of integration of the dependent and explanatory variables, Hadri's (2000) Lagrange multiplier (LM) test is employed. Unlike the conventional panel unit root tests, the Hadri test has a null hypothesis of stationarity across all panels. Hadri argues that the null hypothesis of stationarity produces a more powerful test than other unit root approaches (Lee 2005). The test statistics for Hadri test can be written as:

$$\widehat{LM} = \frac{1}{N}\sum_{i=1}^{n}\left(\frac{\frac{1}{T^2}\sum_{t=1}^{T} S_{it}^2}{\hat{\sigma}_{\varepsilon}^2}\right), S_{it} = \sum_{j=1}^{t}\hat{\varepsilon}_{ij} \quad \text{(eq. \#5)}$$

The unit root results from the Hadri tests are presented in tables 3 and 4. Results show that the null hypothesis of full panel stationarity is rejected for all monthly and quarterly variables in levels. The null hypothesis is not rejected when the same test to the first differences of monthly variables is applied. However, the first difference of $IPYOY$ and $DRATIO$ are not found to be stationary at least by one of the two tests applied to the quarterly dataset and therefore the level of integration for these two variables is undetermined.

Table 3: Hadri Panel Unit Root Tests Using Monthly Data (1997m3–2015m9)

Variable	Intercept	Intercept and Trend	Determination
GB2	29.47***	10.94***	Nonstationary in level,
ΔGB2	-1.76	-0.49	stationary in first difference.
GB10	32.17***	13.97***	Nonstationary in level,
ΔGB10	-1.73	-1.14	stationary in first difference.
STIR	41.04***	12.22***	Nonstationary in level,
ΔSTIR	-1.92	-1.30	stationary in first difference.
INFLYOY	5.98***	6.64***	Nonstationary in level,
ΔINFLYOY	-2.24	-2.01	stationary in first difference.
IPYOY	3.58***	3.56***	Nonstationary in level,
ΔIPYOY	-3.09	-3.52	stationary in first difference.

Notes: 1) *** represents statistical significance at the 1 percent level. 2) The null hypothesis of the Hadri (2000) test is that all the panels are stationary.

Table 4: Hadri Panel Unit Root Tests Using Quarterly Data (2000q1–2015q2)

Variable	Intercept	Intercept and Trend	Determination
GB2	16.44***	6.24***	Nonstationary in level,
ΔGB2	-1.79	-0.58	stationary in first difference.
GB10	18.31***	8.44***	Nonstationary in level,
ΔGB10	-1.42	-0.81	stationary in first difference.
STIR	22.43***	6.69***	Nonstationary in level,
ΔSTIR	-1.56	-1.27	stationary in first difference.
INFLYOY	5.51***	3.95***	Nonstationary in level,
ΔINFLYOY	-1.82	-0.92	stationary in first difference.
IPYOY	2.95***	2.94***	Undetermined
ΔIPYOY	0.18	6.23***	
DRATIO	11.62***	11.27***	Undetermined
ΔDRATIO	5.48***	4.83***	

Notes: 1) *** represents statistical significance at the 1 percent level. 2) The null hypothesis of the Hadri (2000) test is that all the panels are stationary.

Based on the unit root results, an estimation procedure is required that allows for nonstationarity and can estimate the long-run relationships between long-term government bond yields and other relevant variables.

The pooled mean group: The dynamics of government bond yields are examined by applying the pooled mean group (PMG) technique developed by Pesaran, Shin, and Smith (1999). This technique incorporates nonstationary variables and utilizes an error-correction (EC) approach that distinguishes between the long-run (cointegrating) relationship and the short-run adjustment process. Unlike the conventional panel cointegration approaches, the PMG technique does not require nonstationarity across all panels. The PMG procedure has a number of advantages over other cointegration approaches. First, the PMG estimation allows the long-run coefficients to be the same across panels and the short-run coefficients to vary. In the PMG estimation, a long-run equation is estimated by pooling the data for all countries, and individual short-run equations are estimated for each country and averaged to determine the short-run coefficients for the sample. Therefore, the PMG technique makes effective use of the available data. Second, Pesaran, Shin, and Smith (1999) argue that the PMG approach is less sensitive to extreme coefficient values at the panel level. This is particularly important for this paper, as the dataset includes the period of the financial crisis in the eurozone (the exact period has been provided earlier in the "data" section of the paper).

The dependent variable y for t=1, 2, . . ., T time periods and i=1, 2, . . ., N in the unrestricted specification for the autoregressive distributed lags (ARDL) system of equations takes the following form:

$$y_{it} = \sum_{j=1}^{m} \delta_{ij} y_{i,t-j} + \sum_{j=0}^{n} \sigma'_{ij} x_{i,t-j} + \rho_i + \varepsilon_{it} \qquad \text{(eq. \#6)}$$

where x_{ij} is the (k×1) vector of control variables for group i. ρ_i represents the fixed effects and ε_{it} represents the vector of standard errors. This can be an unbalanced panel and m and n may vary across countries. Within a vector EC model (VECM), this system of equations can be reparametrized as follows:

$$\Delta y_{it} = \theta_i \left(y_{i,t-1} - \beta'_i x_{i,t-1} \right) + \sum_{j=1}^{m-1} \gamma_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{n-1} \gamma'_{ij} x_{i,t-j} + \rho_i + \varepsilon_{it} \qquad \text{(eq. \#7)}$$

where x_i is the vector of nonstationary variables for group i and θ_i is the EC coefficient. β'_i represents the long-run parameters, and finally, γ_{ij} and γ'_{ij} represent country-specific short-run coefficient vectors. The pooled group restriction is that the elements of β are common across countries. Therefore,

$$\Delta y_{it} = \theta_i \left(y_{i,t-1} - \beta' x_{i,t-1} \right) + \sum_{j=1}^{m-1} \gamma_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{n-1} \gamma'_{ij} x_{i,t-j} + \rho_i + \varepsilon_{it} \qquad \text{(eq. \#8)}$$

Estimation of this model is by maximum likelihood. Parameter estimates of this model are consistent and asymptotically normal for both stationary and nonstationary $I(1)$ regressors. The EC term and all the dynamics of this model are free to vary. To ensure stability of the long-run equation, it is important to select the correct lag length order of the short-run equations. Here the lag length order has been selected by applying the Akaike information criterion (AIC).

3.2.2 The Methodology for Country-Specific Time-Series Estimations

The ADF test: As discussed above, given the long T for both monthly and quarterly datasets, the test of stationarity of all variables is applied. Different versions (with no constant and trend, constant and no trend, and constant and trend) of the augmented Dickey–Fuller (1979 and 1981) tests are applied to check for unit roots. All of these tests produce similar results. However, due to space constraints, only the results with constant and no trend are presented here (in tables 5 and 6). All remaining results are available upon request. Most variables, except IPIYOY, are nonstationary at levels but are stationary at first differences. IPYOY is found to be stationary at levels for all countries except Greece.

The ARDL bounds test: Since all regressors in the models are not purely I(0) or I(1), this calls for an appropriate technique that is not constrained by the outcomes of unit root tests. The ARDL bounds test method proposed by Pesaran and Shin (1998) and Pesaran, Shin, and Smith (2001) is used to identify the long-run determinants of long-term bond yields in the 11 eurozone member countries. This approach allows regressors to take different optimal numbers of lags, which makes it attractive over the standard cointegration techniques, such as Johansen cointegration (Johansen and Juselius 1990). Paul, Uddin, and Norman (2011) give a detailed explanation of the ARDL bounds tests. The approach provides 95 percent critical bounds for the F-statistics. The bounds-testing approach involves two stages, in which a long-run relationship between the variables under investigation is tested in the first stage. To reject the null hypothesis of no cointegration, the calculated F-statistic has to be greater than the upper bound. If the cointegrating relationship is found in the first stage, the coefficients of long-run relations are estimated in the following stage. As mentioned in Pesaran and Shin (1998), the ARDL technique produces consistent estimates of the long-run coefficients irrespective of the level of integration of the regressors. The AIC is used to determine the lag length order of the ARDL model(s). The EC coefficient is calculated in the second stage. The sign of the EC term has to be negative and significant for the convergence of the dynamics to the long-run equilibrium.

Table 5: ADF Unit Root Tests Using Monthly Data (with intercept)

Country	GB2	ΔGB2	GB10	ΔGB10	STIR	ΔSTIR	INFLYOY	ΔINFLYOY	IPY0Y	ΔIPYOY
Austria	-0.55	-12.61***	-0.13	-17.08***	-1.25	-10.91***	-2.39	-15.30***	-4.71***	-8.09***
Belgium	-1.89	-13.63***	-1.25	-15.07***	-2.75*	-17.32***	-2.83*	-14.90***	-4.53***	-8.92***
Finland	-2.00	-13.82***	-1.64	-13.06***	-1.34	-11.81***	-2.03	-16.09***	-4.03***	-9.00***
France	-1.20	-14.81***	-0.70	-17.48***	-1.68	-16.08***	-2.66*	-6.69***	-3.89***	-8.97***
Germany	-0.56	-13.94***	-0.53	-19.26***	-1.59	-14.40***	-2.89**	-17.57***	-4.72***	-8.18***
Greece	-1.33	-14.15***	-2.63*	-6.34***	-2.03	-14.96***	-2.03	-14.96***	-3.52***	-7.86***
Ireland	-1.50	-7.10***	-1.11	-16.14***	-2.12	-12.16***	-1.57	-5.17***	-3.05**	-8.44***
Italy	-1.49	-17.31***	-1.72	-14.71***	-1.02	-16.27***	-1.83	-14.10***	-4.35***	-6.98***
Netherlands	-0.66	-16.12***	0.02	-9.15***	-0.83	-11.74***	-1.89	-14.24***	-5.01***	-8.86***
Portugal	-3.73***	-4.23***	-1.47	-11.12***	-1.76	-18.92***	-1.95	-13.44***	-3.56***	-7.70***
Spain	-0.90	-17.62***	-1.60	-15.89***	-1.67	-14.46***	-2.36	-11.85***	-3.68***	-8.29***

Notes: 1) ***, **, and * represent statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. 2) The null hypothesis of the ADF is that the series contains unit roots.

Table 6: ADF Unit Root Tests Using Quarterly Data (with intercept)

Country	GB2	ΔGB2	GB10	ΔGB10	STIR	ΔSTIR	INFLYOY	ΔINFLYOY	IPY0Y	ΔIPYOY	DRATIO	ΔDRATIO
Austria	-2.19	-7.17***	-0.17	-9.34***	-2.13	-7.10***	-3.39**	-7.04***	-3.90***	-6.22***	-1.68	-3.64***
Belgium	-0.99	-7.81***	-1.40	-9.00***	-1.63	-12.74***	-3.03**	-7.53***	-7.21***	-7.35***	-1.84	-2.26
Finland	-0.86	-8.14***	-2.16	-8.58***	-1.31	-10.21***	-2.10	-9.23***	-3.29**	-10.66***	-0.83	-9.33***
France	-0.59	-6.65***	-0.47	-10.01***	-1.33	-10.46***	-1.77	-5.67***	-4.00***	-7.55***	0.24	-2.82*
Germany	-1.36	-7.36***	-0.36	-9.70***	-1.67	-7.87***	-3.30**	-9.16***	-3.95***	-8.95***	-0.86	-7.44***
Greece	-1.68	-10.11***	-2.49	-10.08***	-8.78***	-31.80***	-2.08	-6.07***	-2.08	-6.63***	-0.52	-8.99***
Ireland	-1.51	-5.68***	-1.28	-10.12***	-1.55	-12.00***	-2.19	-7.25***	-3.09**	-7.87***	-2.95**	-1.15
Italy	-0.62	-9.12***	-1.79	-5.26***	-1.07	-11.97	-1.74	-4.88***	-3.14**	-6.82***	-0.54	-1.95
Netherlands	-3.35**	-4.86***	-0.51	-8.58***	-1.20	-7.19***	-3.12**	-7.24***	-2.86*	-6.81***	-0.18	-6.62***
Portugal	-1.10	-8.37***	-1.94	-8.06***	-1.66	-11.57***	-1.55	-12.11***	-2.67*	-7.35***	1.23	-6.30***
Spain	-2.12	-7.77***	-1.72	-5.61***	-1.66	-7.40***	-0.35	-6.93***	-3.75***	-7.39***	0.05	-2.90*

Notes: 1) ***, **, and * represent statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively. 2) The null hypothesis of the ADF is that the series contains unit roots.

IV: EMPIRICAL FINDINGS

Two sets of findings are reported here using the appropriate methodologies for the relevant datasets. First, the findings from the panel datasets are provided. Second, the findings from time-series analysis are presented.

4.1 Results from the Panel Analysis

Table 7 presents the results from estimating the yield of GB2 and GB10 equations when the monthly dataset is used in the panel. The EC term from the PMG estimator is negative and statistically significant, which is desirable. The negative and significant coefficient of EC implies the convergence of the variables to their long-run equilibrium path. The magnitude of the coefficients suggests a modest speed of EC: that is, approximately 3 to 5 percent of any deviation from the equilibrium will be corrected in the first month.

Table 7: Pooled Mean Group Results Using Monthly Data

Variable	Dependent Variable: GB2	Dependent Variable: GB10
	Long-Run Equation	
INFLYOY	-0.45*** (0.10)	-0.33** (0.16)
IPYOY	0.03* (0.02)	-0.07** (0.03)
STIR	0.87*** (0.06)	0.86*** (0.10)
	Short-Run Equation	
Constant	0.12** (0.06)	0.06*** (0.01)
EC	-0.05*** (0.01)	-0.03*** (0.00)
$\Delta GB2_{-1}$	0.04 (0.04)	-
$\Delta GB2_{-2}$	0.02 (0.04)	-
$\Delta GB2_{-3}$	0.01 (0.04)	-
$\Delta GB10_{-1}$	-	0.02 (0.02)
$\Delta GB10_{-2}$	-	-0.05 (0.04)
$\Delta GB10_{-3}$	-	0.05** (0.03)
ΔINFLYOY	-0.20 (0.30)	-0.08*** (0.02)
$\Delta INFLYOY_{-1}$	0.15** (0.07)	0.10*** (0.02)
ΔIPYOY	0.03 (0.02)	-0.00** (0.00)
$\Delta IPYOY_{-1}$	-0.05 (0.04)	-0.01 (0.00)
ΔSTIR	0.70*** (0.09)	0.32*** (0.04)
$\Delta STIR_{-1}$	-0.14** (0.07)	-0.22*** (0.04)
Number of Observations	2437	2454
Selected Model	ARDL(4,2,2,2)	ARDL(4,2,2,2)
Time Period	1997m5-2015m9	1997m3-2015m9

Notes: 1) ***, **, and * represent statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. 2) Standard errors are in parentheses. 3) Appropriate model was selected using the AIC.

Over the long run, INFLYOY is negatively related to the yields of GB2 and GB10. Coefficients of these variables are significant at the 1 percent and 5 percent level with the magnitudes of 0.45 and 0.33, respectively. A rise in inflation leads to a fall in long-term bond yields in the long run. This is contrary to the view that inflation and inflationary expectations exert an upward pressure on government bonds yields. However, if the ECB hikes (reduces) its benchmark policy rate in the face of upward (downward) inflationary pressures or in anticipation of a rise (decline) in inflationary expectations, short-term interest rates would be collinear with inflation. Hence, the coefficient on inflation may not be of the expected sign. The long-run coefficient of IPYOY is positive and significant (only at the 10 percent level) in the GB2 equation, but negative and significant (at the 5 percent level) in the GB10 equation.

The most important long-run determinant of the yields of GB2 and GB10 is the STIR. This is in concordance with the Keynesian view. The coefficients of this variable are always positive and significant at the 1 percent level. The size of the coefficients suggests that approximately 86 to 87 percent of the movements of the yields of GB2 and GB10 can be explained by the movements of STIR. Furthermore, the most important short-run determinant of long-term bond yields is the first difference of STIR.

Results from the quarterly dataset are presented in table 8. The negative and significant coefficients of the EC suggest that the long-run equations have empirical supports. Although small in magnitude, the coefficients of IPYOY are positive and significant at the 1 percent level. STIR is positive and significant at the 1 percent level. The size of this coefficient is between from 0.64 (for GB10) to 0.80 (for GB2). These results reinforce the previous findings from the monthly variables. Inflationary pressures appear to have no significant effect on GB2 and only a marginally negative effect (only at the 10 percent level) on GB10.

Table 8: Pooled Mean Group Results Using Quarterly Data

Variable	Dependent Variable: GB2	Dependent Variable: GB10
	Long-Run Equation	
INFLYOY	0.00 (0.07)	-0.23* (0.13)
IPYOY	0.08*** (0.02)	0.12*** (0.03)
DRATIO	-0.01** (0.00)	-0.03** (0.01)
STIR	0.80*** (0.04)	0.64*** (0.08)
	Short-Run Equation	
Constant	0.41*** (0.05)	0.65*** (0.06)
EC	-0.30*** (0.06)	-0.15*** (0.02)
$\Delta GB2_{-1}$	-0.03 (0.07)	-
ΔINFLYOY	0.29* (0.17)	0.15*** (0.05)
$\Delta INFLYOY_{-1}$	-0.10 (0.14)	0.20** (0.09)
$\Delta INFLYOY_{-2}$	-0.24 (0.19)	-
$\Delta INFLYOY_{-3}$	0.29 (0.33)	-
ΔIPYOY	-0.23 (0.21)	-0.01 (0.01)
$\Delta IPYOY_{-1}$	-0.10 (0.09)	0.00 (0.01)
$\Delta IPYOY_{-2}$	-0.03 (0.02)	-
$\Delta IPYOY_{-3}$	0.05 (0.05)	-
ΔDRATIO	0.09 (0.09)	0.03 (0.02)
$\Delta DRATIO_{-1}$	-0.04 (0.05)	0.02 (0.02)
$\Delta DRATIO_{-2}$	-0.05** (0.02)	-
$\Delta DRATIO_{-3}$	0.55 (0.54)	-
ΔSTIR	1.40*** (0.54)	0.34*** (0.05)
$\Delta STIR_{-1}$	-1.06** (0.46)	-0.43*** (0.13)
$\Delta STIR_{-2}$	0.56 (0.47)	-
$\Delta STIR_{-3}$	-0.61* (0.35)	-
Number of Observations	635	657
Selected Model	ARDL(2,4,4,4,4)	ARDL(1,2,2,2,2)
Time Period	2000q1-2015q2	2000q3-2015q2

Notes: 1) ***, **, and * represent statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. 2) Standard errors are in parentheses. 3) Appropriate model was selected using the AIC.

The ratio of government debt to nominal GDP (a measure of government finance) is included in the quarterly equations. The coefficients of this variable are always negative and significant at the 5 percent level in both the GB2 and GB10 equations. Therefore, contrary to the orthodox view, the debt ratio does not exert any upward pressure on long-term bond yields in eurozone countries.

In the next two tables (tables 9 and 10), the results from the PMG estimations are provided incorporating a dummy variable for the financial crisis period in all the models. These results echo the earlier findings. The CRISIS dummy is insignificant in three out of four of the estimated equations. However, this variable is positive and significant when the quarterly dataset is used for the GB10 equation.

Table 9: Pooled Mean Group Results with CRISIS Dummy Using Monthly Data

Variable	Dependent Variable: GB2	Dependent Variable: GB10
	Long-Run Equation	
INFLYOY	-0.04 (0.08)	0.19 (0.12)
IPYOY	0.00 (0.02)	-0.06** (0.03)
STIR	0.68*** (0.06)	0.40*** (0.08)
	Short-Run Equation	
Constant	0.10*** (0.03)	0.13*** (0.04)
EC	-0.08*** (0.02)	-0.05*** (0.01)
$\Delta GB2_{-1}$	0.04 (0.04)	-
$\Delta GB2_{-2}$	0.01 (0.03)	-
$\Delta GB2_{-3}$	0.01 (0.03)	-
$\Delta GB10_{-1}$	-	0.01 (0.02)
$\Delta GB10_{-2}$	-	-0.07* (0.03)
$\Delta GB10_{-3}$	-	0.05* (0.03)
ΔINFLYOY	-0.18 (0.26)	0.07*** (0.01)
$\Delta INFLYOY_{-1}$	0.18 (0.12)	0.10*** (0.03)
ΔIPYOY	-0.02 (0.02)	-0.00 (0.00)
$\Delta IPYOY_{-1}$	-0.04 (0.04)	-0.00 (0.00)
ΔSTIR	0.68*** (0.05)	0.32*** (0.04)
$\Delta STIR_{-1}$	-0.17*** (0.05)	-0.22*** (0.04)
CRISIS	1.04 (0.77)	0.32 (0.26)
Number of Observations	2437	2454
Selected Model	ARDL(4,2,2,2)	ARDL(4,2,2,2)
Time Period	1997m5-2015m9	1997m3-2015m9

Notes: 1) ***, **, and * represent statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. 2) Standard errors are in parentheses. 3) Appropriate model was selected using the AIC.

Table 10: Pooled Mean Group Results with CRISIS Dummy Using Quarterly Data

Variable	Dependent Variable: GB2	Dependent Variable: GB10
	Long-Run Equation	
INFLYOY	0.07 (0.05)	-0.15 (0.10)
IPYOY	0.08*** (0.02)	0.10*** (0.03)
DRATIO	-0.01*** (0.00)	-0.00 (0.01)
STIR	0.75*** (0.04)	0.88*** (0.06)
	Short-Run Equation	
Constant	0.69*** (0.14)	0.43*** (0.07)
EC	-0.41*** (0.08)	0.26*** (0.03)
$\Delta GB2_{-1}$	-0.04 (0.07)	-
ΔINFLYOY	0.44 (0.27)	0.24** (0.11)
$\Delta INFLYOY_{-1}$	-0.06 (0.13)	0.16 (0.11)
$\Delta INFLYOY_{-2}$	-1.33 (1.20)	-0.01 (0.07)
$\Delta INFLYOY_{-3}$	-0.57 (0.48)	0.01 (0.10)
ΔIPYOY	-0.28 (0.26)	-0.02* (0.01)
$\Delta IPYOY_{-1}$	-0.22 (0.21)	0.01 (0.01)
$\Delta IPYOY_{-2}$	-0.08 (0.07)	-0.00 (0.01)
$\Delta IPYOY_{-3}$	0.05 (0.05)	0.00 (0.01)
ΔDRATIO	-0.42 (0.43)	0.01 (0.02)
$\Delta DRATIO_{-1}$	-0.55 (0.56)	0.02 (0.02)
$\Delta DRATIO_{-2}$	-0.58 (0.53)	0.01 (0.02)
$\Delta DRATIO_{-3}$	0.22 (0.21)	0.02 (0.02)
ΔSTIR	2.41 (1.65)	0.38*** (0.08)
$\Delta STIR_{-1}$	-1.63 (1.04)	-0.81*** (0.09)
$\Delta STIR_{-2}$	0.28 (0.23)	0.15 (0.09)
$\Delta STIR_{-3}$	-2.11 (1.88)	-0.29*** (0.09)
CRISIS	4.75 (3.96)	0.80*** (0.30)
Number of Observations	635	635
Selected Model	ARDL(2,4,4,4,4)	ARDL(1,4,4,4,4)
Time Period	2001q1-2015q2	2000q1-2015q2

Notes: 1) ***, **, and * represent statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. 2) Standard errors are in parentheses. 3) Appropriate model was selected using the AIC.

It is clear from the panel results that the most important determinant of the long-term bond yields in eurozone member countries is the short-term interest rates. This is in concordance with the Keynesian view.

4.2 Country-Specific Time-Series Results

The next task is to examine whether the findings from the panel analyses are different from the country-specific time-series results. Individual regressions for all 11 eurozone countries are estimated using the ARDL bounds test technique.

The ARDL bounds test results estimated using monthly variables are presented in table 11. The computed F-statistics, based on the Wald test, do not exceed the upper bound value for any of the 11 eurozone countries. Hence, there does not appear to be any statistically discernable long-run relationship when the monthly dataset is used for estimations.

Table 11: F-Statistics from ARDL Estimations Using Monthly Data

	F- Statistics	
Country	**GB2**	**GB10**
Austria	3.24	2.12
Belgium	1.07	1.03
Finland	1.56	1.35
France	0.68	1.32
Germany	1.16	1.19
Greece	2.73	2.11
Ireland	2.23	1.27
Italy	2.87	3.36
Netherlands	0.44	1.61
Portugal	1.71	1.11
Spain	2.04	1.99

Notes: Lower bound: 10 percent: 2.72; 5 percent: 3.23; 1 percent: 4.29. Upper bound: 10 percent: 3.77; 5 percent: 4.35; 1 percent: 5.61.

However, France, Greece, and Ireland exhibit evidence of long-run relationships between INFLYOY, IPYOY, DRATIO, STIR, and both GB2 and GB10 when quarterly variables are used for estimations, as shown in the results presented in table 12. Moreover, there are long-run relationships between INFLYOY, IPYOY, DRATIO, STIR, and GB2 in Spain, and between INFLYOY, IPYOY, DRATIO, STIR, and GB10 in the Netherlands and Portugal.

Table 12: F-Statistics from ARDL Estimations Using Quarterly Data

	F- Statistics	
Country	**GB2**	**GB10**
Austria	3.08	3.33
Belgium	2.37	1.21
Finland	1.82	1.89
France	**5.43**	**4.91**
Germany	2.28	2.05
Greece	**8.95**	**4.70**
Ireland	**6.79**	**9.88**
Italy	3.44	1.30
Netherlands	3.34	**6.45**
Portugal	1.82	**4.82**
Spain	**3.61**	3.19

Notes: Lower bound: 10 percent: 2.45; 5 percent: 2.86; 1 percent: 3.74. Upper bound: 10 percent: 3.52; 5 percent: 4.01; 1 percent: 5.06.

Based on the above results, the next step involves the estimation of the long-run coefficients of STIR and other control variables using quarterly data. The results are presented in tables 13 and 14.

Table 13: Long-Run Coefficients from ARDL Estimations for GB2 Using Quarterly Data

Variable	France	Greece	Ireland	Spain
Constant	4.90*** (0.74)	-27.44*** (5.34)	1.82** (0.87)	0.32 (0.52)
EC	-1.33*** (0.26)	-0.63*** (0.14)	-0.42*** (0.10)	-0.63*** (0.14)
INFLYOY	-0.24*** (0.28)	2.42*** (0.46)	0.25** (0.11)	0.23** (0.10)
IPYOY	0.02 (0.01)	0.128 (0.07)	-0.08* (0.04)	0.03 (0.03)
DRATIO	-0.06*** (0.00)	0.17*** (0.03)	-0.01 (0.01)	-0.01 (0.01)
STIR	0.64*** (0.06)	0.95*** (0.28)	0.36* (0.20)	0.77*** (0.09)
Selected Model	ARDL (4,2,0,3,4)	ARDL (4,3,3,2,4)	ARDL (3,3,1,2,3)	ARDL (1,0,0,1,2)
Time Period	2000q4-2015q2	2001q2-2015q2	2000q3-2015q2	2000q2-2015q2

Notes: 1) ***, **, and * represent statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. 2) Standard errors are in parentheses.

Table 14: Long-Run Coefficients from ARDL Estimations for GB10 Using Quarterly Data

Variable	France	Greece	Ireland	Netherlands	Portugal
Constant	7.55*** (2.41)	-198.52 (137.92)	2.22 (0.74)	8.27*** (1.64)	-2.74 (2.35)
EC	-0.40*** (0.10)	-0.08 (0.07)	-0.58*** (0.11)	-0.43*** (0.08)	-0.36*** (0.09)
INFLYOY	-0.27 (0.27)	13.11 (9.69)	0.00 (0.15)	0.24** (0.10)	0.13 (0.37)
IPYOY	0.10** (0.05)	0.53 (0.78)	0.43*** (0.08)	0.10*** (0.03)	0.17 (0.11)
DRATIO	-0.08*** (0.03)	1.26 (0.81)	0.01** (0.01)	-0.12*** (0.03)	0.04** (0.02)
STIR	0.35* (0.21)	4.92 (4.92)	0.57*** (0.20)	0.23 (0.16)	1.03** (0.44)
Selected Model	ARDL (1,4,2,1,4)	ARDL (1,0,0,4,0)	ARDL (4,0,4,4,3)	ARDL (1,0,1,4,2)	ARDL (4,2,1,4,2)
Time Period	2000q2-2015q2	2001q4-2015q2	2001q1-2015q2	2001q1-2015q2	2001q1-2015q2

Notes: 1) ***, **, and * represent statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. 2) Standard errors are in parentheses.

It is evident from the above results that the most important long-run determinant of the yields of GB2 and GB10 is STIR. Whenever significant, this variable is always positive with a large magnitude. The coefficient of the debt ratio is significant and negative for France and the Netherlands, but positive for Greece, Ireland, and Portugal. For other eurozone countries, the effect of DRATIO is not statistically significant. The effect of IPYOY on long-term bond yields is generally positive, but the effect of INFLYOY is inconclusive.

The results from time-series analysis largely reinforce the notion that short-term interest rates are the most important driver of long-term interest rates on government bonds.

V: CONCLUSION AND FURTHER RESEARCH

The results reported in this paper show that short-term interest rates strongly influence long-term interest rates on government bonds in the eurozone member countries, even though these countries lack monetary sovereignty. The empirical results are quite relevant to the debate about the relative importance of the central bank's benchmark policy rate and a nation's government debt ratio in influencing the long-term interest rates of government bonds. These results can inform policy questions related to government debt burden, fiscal sustainability, fiscal policy, the central bank's ability to control long-term interest, and the efficacy of monetary policy.

Further in-depth research on these questions is warranted because there is considerable debate about what the relevant determinants of long-term interest rates are. There are also questions about the resilience, the robustness, and the indeterminate nature of the some of the findings in the empirical literature. Both conceptual and empirical research on the drivers of government bond yields in the eurozone would be useful for formulating, implementing, and evaluating appropriate financial, economic, and structural policies to ensure financial stability, restore investor confidence, and promote economic growth and social well-being in the eurozone.

REFERENCES

Akram, T. 2014. "The Economics of Japan's Stagnation." *Business Economics* 49(3): 156–75.

Akram, T., and A. Das. 2014a. "Understanding the Low Yields of the Long-Term Japanese Sovereign Debt." *Journal of Economic Issues* 48(2): 331–40.

———. 2014b. "The Determinants of Long-Term Japanese Government Bonds' Low Nominal Yields." Levy Institute Working Paper No. 818. Annandale-on-Hudson, NY: Levy Economics Institute of Bard College.

———. 2015a. "Does Keynesian Theory Explain Indian Government Bond Yields?" Levy Institute Working Paper No. 834. Annandale-on-Hudson, NY: Levy Economics Institute of Bard College.

———. 2015b. "A Keynesian Explanation of Indian Government Bond Yields." *Journal of Post Keynesian Economics* 38(4): 565–87.

———. 2017. "The Long-Run Determinants of Indian Government Bond Yields." Levy Institute Working Paper No. 881. Annandale-on-Hudson, NY: Levy Economics Institute of Bard College.

Akram, T., and H. Li. 2016. "The Empirics of Long-Term US Interest Rates." Levy Institute Working Paper No. 863. Annandale-on-Hudson, NY: Levy Economics Institute of Bard College.

———. 2017. "What Keeps Long-Term U.S. Interest Rates So Low?" *Economic Modelling* 60: 380–90.

Baldacci, E., and M. Kumar. 2010. "Fiscal Deficits, Public Debt, and Sovereign Bond Yields." IMF Working Paper No. 10/184. Washington, DC: International Monetary Fund.

Dickey, D.A., and W.A. Fuller. 1979. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *Journal of the American Statistical Association* 74(366): 427–31.

———. 1981. "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root." *Econometrica* 49(4): 1057–72.

Draghi, M. 2012. "Verbatim of the Remarks Made by Mario Draghi." Global Investment Conference, London, July 26. Available at: https://www.ecb.europa.eu/press/key/date/2012/html/sp120726.en.html.

Fullwiler, S.T. 2016. "The Debt Ratio and Sustainable Macroeconomic Policy." *World Economic Review* 7: 12–42.

Gruber, J.W., and S.B. Kamin. 2012. “Fiscal Positions and Government Bond Yields in OECD Countries.” *Journal of Money, Credit, and Banking* 44(8): 1563–87.

Hadri, K. 2000. “Testing for Stationarity in Heterogeneous Panel Data.” *The Econometrics Journal* 3(2): 148–61.

Johansen, S., and K. Juselius. 1990. “Maximum Likelihood Estimation and Inference on Cointegration—with Applications to the Demand for Money.” *Oxford Bulletin of Economics and Statistics* 52(2): 169–10.

Keynes, J.M. 1930. *A Treatise on Money, Vol. II: The Applied Theory of Money*. London: Macmillan.

———. 2007 [1936]. *The General Theory of Employment, Interest, and Money*. New York: Palgrave Macmillan.

Kregel, J. 2011. “Was Keynes’ Monetary Policy *À Outrance* in the Treatise, A Forerunner of ZIRP and QE? Did He Change his Mind in the *General Theory*?” Levy Institute Policy Note No. 4. Annandale-on-Hudson, NY: Levy Economics Institute of Bard College.

Lam, W.R., and K. Tokuoka. 2013. “Assessing the Risks to the Japanese Government Bond (JGB) Market.” *Journal of International Commercial and Economic Policy* 4(1): 1350002–1-1350002-15. Available at: http://dx.doi.org/10.1142/S1793993313500026

Lee, C.C. 2005. “Energy Consumption and GDP in Developing Countries: A Cointegrated Panel Analysis.” *Energy Economics* 27(3): 415–27.

Macrobond. various years. Macrobond subscription services. Available at: https://www.macrobond.com/

Mitchell, W. 2015. *Eurozone Dystopia: Groupthink and Denial on a Grand Scale.* Northampton, MA: Edward Elgar Publishing.

Nelson, C.R., and C.R. Plosser. 1982. “Trends and Random Walks in Macroeconmic Time Series: Some Evidence and Implications.” *Journal of Monetary Economics* 10(2): 139–62.

Paul, B.P., M.G.S. Uddin, and A.M. Noman. 2011. “Remittances and Output in Bangladesh: An ARDL Bounds Testing Approach to Cointegration.” *International Review of Economics* 58(2): 229–42.

Pesaran, M.H., and Y. Shin. 1998. “An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis.” *Econometric Society Monographs* 31: 371–413.

Pesaran, M.H., Y. Shin, and R.P. Smith. 1999. “Pooled Mean Group Estimation of Dynamic Heterogeneous Panels.” *Journal of the American Statistical Association* 94(446): 621–34.

Pesaran, M.H., Y. Shin, and R.J. Smith. 2001. “Bounds Testing Approaches to the Analysis of Level Relationships.” *Journal of Applied Econometrics* 16(3): 289–326.

Phillips, P.C.B., and P. Perron. 1988. “Testing for a Unit Root in Time Series Regression.” *Biometrika* 75(2): 335–46.

Poghosyan, T. 2014. “Long-Run and Short-Run Determinants of Sovereign Bond Yields in Advanced Economies.” *Economic System* 38(1): 100–14.

Reinhart, C.M., and K.S. Rogoff. 2009. *This Time is Different: Eight Centuries of Financial Folly*. Princeton, NJ: Princeton University Press.

Riefler, W.W. 1930. *Money Rates and Money Markets in the United States*. New York and London: Harper & Brothers.

Sims, C.A. 2012. “Gaps in the Institutional Structure of the Euro Area.” Unpublished manuscript. Available at: http://sims.princeton.edu/yftp/EuroGaps/EuroGaps.pdf

———. 2013. “Paper Money.” *American Economic Review* 103(2): 563–84.

Stiglitz, J.E. 2016. *The Euro: How a Common Currency Threatens the Future of Europe*. New York and London: WW Norton & Company.

Tokuoka, K. 2012. “Intergenerational Implications of Fiscal Consolidation in Japan.” IMF Working Paper No. 12/197. Washington, DC: International Monetary Fund.

Woodford, M. 2001. “Fiscal Requirements for Price Stability.” *Journal of Money, Credit and Banking* 33(3): 669–728.

Wray, L.R. 2003 [1998]. *Understanding Modern Money: The Key to Full Employment and Price Stability*, paperback edition. Cheltenham, UK and Northampton, MA: Edward Elgar.

———. 2012. *Modern Money Theory: A Primer on Macroeconomics for Sovereign Monetary Systems*. New York: Palgrave Macmillan.