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Abstract

We assess public finances solvency for Euro Area countries using quarterly data between 1999Q1 and 2020Q4. Through a country-by-country analysis, the answer to the title question is true. For most countries, (i) the primary budget balance reacts positively to the lagged public debt ratio and past primary government balances contribute to the reduction of the public debt ratio, indicating a Ricardian fiscal regime. Furthermore, in a panel framework: (ii) the response of revenues to government expenditures is higher from 2010 onwards, and, for higher average public debt ratios, the response is lower, while (iii) the response of the primary government balance to the lagged public debt ratio is lower from 2010 onwards and is higher for higher average public debt ratios; (iv) past primary budget balances allow the public debt ratio to be reduced, especially before 2010 and in countries whose average public debt ratio is between 60 and 90% of GDP. Using a rolling window method, we find that (v) fiscal sustainability coefficients are higher the higher the lagged public debt ratios, fiscal rule indexes and sovereign ratings. Conversely, after 2010 and in periods of legislative elections, those coefficients are lower.

JEL-Codes: C230, H610, H630, E620.

Keywords: fiscal sustainability, primary budget balance, public debt, panel data, rolling windows, Euro Area, quarterly fiscal data.

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1. Introduction

The sustainability of public finances in the Economic and Monetary Union (EMU) has been object of particular attention by economic policy makers, at least since the Global and Financial Crisis (GFC) of 2008-2009 and the Eurozone crisis in 2010. With political and economic uncertainties and challenges (health crisis, war) having an expected toll on public finances, the issue continues to be paramount notably in the Euro Area.

The theoretical and empirical literature has devoted much research to this topic. The analysis of fiscal sustainability has been typically threefold: studying the properties of the public debt series (following the methodology popularized by Hamilton and Flavin, 1986); examining the long-term relationship between government revenues and expenditures (Hakkio and Rush, 1991); and estimation of so-called fiscal reaction functions (Bohn, 1998; Canzoneri *et al.*, 2001).

In accordance with the institutional framework of the Eurozone, the policy authorities are concerned with stabilizing public debt and aim to ensure a sustainable path for public finances. The obligation to comply with fiscal rules is related to the mandate of the European Central Bank (ECB) to achieve price stability. This makes the fiscal regime prevailing in the EMU Ricardian de jure. Hence, and in order to respect the present-value budget constraint, the primary budget balance is expected to react positively to the government debt stock.

In this paper, we contribute to the literature by performing an analysis of the relationship between government revenues and expenditures, and between primary budget balances and public debt-to-GDP ratio for a sample of 19 European countries using quarterly data from 1999Q1 to 2020Q4. Moreover, we combine a country level analysis with a panel framework, by looking at the first-differenced stock of public debt, analysing cointegration relationships between government revenues and expenditures and primary government balance and lagged public debt ratio and estimating fiscal reaction functions. The country specific analysis makes it possible to open the black box, in order to find different profiles of fiscal sustainability and fiscal regimes among the Euro Area countries. The panel analysis is justified given the existence of a single monetary policy among the Eurozone countries, a common fiscal framework, the integration of financial markets and the feedback and spillover effects between the economies.

Furthermore, we estimate the responses of the primary government balance to changes in the public debt-to-GDP ratio, using a rolling window method, and then identify the factors that explain these marginal responses. Therefore, this article aims to provide a comprehensive view of fiscal sustainability applied to Eurozone countries, using a quarterly data frequency.

Such an exercise makes it possible to overcome the gap in the literature in this regard and also constitutes another added value of this work.

The remainder of the paper is structured as follows. Section 2 presents a brief literature review. Section 3 explains the empirical strategy. Section 4 describes the data. Section 5 reports and discusses the empirical results obtained. Section 6 concludes.

2. Literature

Sargent and Wallace (1981) define that, in a Ricardian fiscal regime or monetary-dominant regime, monetary policy is active and fiscal policy is passive. In addition, there are also non-Ricardian or fiscal-dominance regimes, in which fiscal policy is active and monetary policy is passive. More specifically, in these regimes, the government chooses the primary budget balance independently of the public debt-to-GDP ratio, and prices endogenously adjust to guarantee the government budget constraint.

Through the Fiscal Theory of the Price Level (FTPL), Leeper (1991), Sims (1994) and Woodford (1994, 1995) elaborate the theoretical background of non-Ricardian fiscal regimes. In this context, the government can autonomously decide on the levels of the fiscal balance and public debt and the price level adjusts to the level of public debt to ensure compliance with the government intertemporal budget constraint. The empirical tests of the FTPL can be performed using a backward-looking approach (Bohn, 1998) and a forward-looking approach (Canzoneri *et al.*, 2001).

In the empirical literature, fiscal sustainability analysis was initially applied to individual countries, based on unit root tests and the study of cointegration relationships between the two sides of the budget. Later, studies emerged using a panel data structure from a relatively wide range of countries, employing standard panel techniques and examining panel cointegration relationships. The use of data with an annual frequency is a common approach (see, for instance, Afonso (2005) for European Union countries), however, we also find the use of quarterly data. For example, Hakkio and Rush (1991), Haug (1995) and Quintos (1995) study this issue for the United States, Olekalns (2000) for Australia, and Hatemi (2002) for Sweden. These authors test the existence of cointegration between government revenues and expenditures, comprising time horizons between the end of the Second World War and the 2000s.

Afonso and Jalles (2017), in turn, focus the analysis on 11 countries of the Eurozone, between 1999 and 2013, concluding that fiscal policy has been sustainable only in the cases of Belgium, France, Germany and the Netherlands. Moreover, the authors construct time-varying

coefficients of the response of the primary government balance to the public debt ratio and find that the global financial crisis has a negative impact and expenditure-base fiscal rules have a positive effect. More recently, Mackiewicz-Łyziak and Łyziak (2019), considering 27 European Union countries from 1996 to 2017, endogenize the long-term real interest rate by testing fiscal sustainability, proposing a synthetic indicator of fiscal sustainability. The main conclusion of the article points to less evidence of solvency of public accounts for the countries under study.

Taking as a sample 28 European Union countries between 1995 and 2021, Afonso *et al.* (2021) estimate panel fiscal reaction functions, confirming the existence of a Ricardian fiscal regime, with greater relevance in the period after the global financial crisis. By introducing the differential between the long-term real interest rate and the economic growth rate into the analysis, and when this is positive, improvements in the primary government balance result in greater decreases in the public debt ratio. However, when the differential is negative, the effect disappears.

3. Empirical Strategy

To test the sustainability of public finances, we can verify the stationarity of series in first differences of the stock of real public debt. In this regard, Trehan and Walsh (1991) state that the stationary of the first differences of the stock of real public debt is a sufficient condition for fiscal sustainability. Nevertheless, according to Bohn (2007), the rejection of stationarity does not necessarily mean the absence of sustainability in the public finances. Thus, the first step of the empirical analysis consists of studying the properties of the series in first differences of the stock of real public debt. In addition to the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, and in order to guarantee robustness and completeness, we also performed the four tests proposed by Ng and Perron (2001) based on the modified information criteria (MIC), namely, the modified PP test MZ_a; the modified PP MZ_t; the modified Sargan-Bhargava test *MSB*; and the modified point optimal test *MPT*. Finally, we complement with the modified ADF test proposed by Vogelsang and Perron (1998), allowing for one endogenously determined break. The null hypothesis is the existence of a unit root against the break stationary alternative hypothesis. In this context, there are two generating mechanisms of shifts, namely, additive outlier (AO) and innovational outlier (IO).

Therefore, we consider the following relationship based on Hakkio and Rush (1991):

$$R_t = \alpha + \beta G_t + \varphi_t \quad (1)$$

where R_t denotes government revenues and G_t corresponds to the government expenditures.

Furthermore, we can test the fiscal reaction function proposed by Bohn (1998):

$$s_t = \gamma + \theta B_{t-1} + \omega_t \quad (2)$$

where s_t is the primary government balance and B_{t-1} is the lagged government debt. φ_t and ω_t are iid disturbance terms satisfying standard assumptions of zero mean and constant variance.

If the series under study are non-stationary, the relevant question is whether a linear combination of two pairs of variables is stationary. With such a combination, government revenues and expenditures and the primary government balance and lagged government debt are cointegrated. More specifically, variables are attracted to a long-term equilibrium and any deviation from this relationship reflects a temporary (short-term) imbalance. The existence of positive and significant coefficients β and θ in equations (1) and (2), respectively, is a sufficient condition for fiscal solvency.

Specifically, we test for cointegration between government revenues and expenditures and primary government balance and government debt through the Johansen-Juselius cointegration test. This methodology estimates the long-term attracting set in a Vector Auto-Regressive (VAR) context that incorporates the short and long-run dynamics of the several models.

In order to estimate the parameters β and θ of equations (1) and (2), respectively, we used the Dynamic Ordinary Least Squares (DOLS) method of Stock and Watson (1993). This method provides a robust correction to the possible presence of endogeneity in the explanatory variable as well as of serial correlation in the error terms of the ordinary least squares estimation. We first estimate the long-run dynamic equation including leads and lags of the explanatory variable and then perform Shin's (1994) test from the calculation of C_μ, a Lagrange Multiplier (LM) statistic from the dynamic ordinary least squares residuals that tests for deterministic cointegration, that is, no trend is present in the regression.

Using the Pesaran (2006) Common Correlated Effects Mean Group Estimator (CCEMG), we estimate, in a panel setup, the relationship between government revenues and expenditures, as well as the fiscal reaction functions, following the approaches of Bohn (1998) and Canzoneri *et al.* (2001).[1] In this context, the specifications of the estimated models are as follows:

[1] The Pesaran (2006) CCEMG is a non-stationary panel data econometric technique that allows for cross-section dependence and accounts for the presence of unobserved heterogeneity. This method considers the cross-section means of the slope coefficients, using the mean group (MG) estimator proposed by Pesaran and Smith (1995). The

$$R_{i,t} = \alpha_0 + \alpha_1 R_{i,t-4} + \alpha_2 G_{i,t} + \alpha_3 Z_{i,t} + u_{i,t} \quad (3)$$

$$s_{i,t} = \beta_0 + \beta_1 s_{i,t-4} + \beta_2 b_{i,t-4} + \beta_3 Z_{i,t} + \varepsilon_{i,t} \quad (4)$$

$$b_{i,t} = \delta_0 + \delta_1 b_{i,t-4} + \delta_2 s_{i,t-4} + \delta_3 Z_{i,t} + \sigma_{i,t} \quad (5)$$

where $R_{i,t}$ corresponds to the government revenues as a percentage of GDP of country *i* in quarter *t*; $R_{i,t-4}$ is the government revenues as a percentage of GDP of country *i* in the same quarter of the previous year (*t-4*); $G_{i,t}$ denotes the government expenditures as a percentage of GDP of country *i* in quarter *t*; $s_{i,t}$ corresponds to the primary government balance as a percentage of GDP of country *i* in quarter *t*; $s_{i,t-4}$ is the primary government balance as a percentage of GDP of country *i* in quarter *t-4*; $b_{i,t-4}$ denotes the government debt as a percentage of GDP of country *i* in quarter *t-4*; $b_{i,t}$ corresponds to the government debt as a percentage of GDP of country *i* in quarter *t*; and Z_t is the output gap of country *i* in quarter *t*. u_t, ε_t and σ_t are iid disturbance terms satisfying standard assumptions of zero mean and constant variance.

The presence of lagged terms of the explained variables aims to capture their persistence and the introduction of the output gap as an explanatory variable seeks to control the cyclical fluctuations of the output

If $\beta_2 < 0$, the primary government balance does not react to the level of public debt, with a non-Ricardian fiscal regime in force. On the other hand, if $\beta_2 > 0$, the primary government balance reacts to the existing public debt stock, signalling the existence of a Ricardian fiscal regime. If $\delta_2 < 0$, the hypothesis of a Ricardian fiscal regime being verified is not rejected, since the government uses past primary budget surpluses to reduce the current stock of public debt. Instead, $\delta_2 \geq 0$, there is a fiscal predominance regime, that is, a non-Ricardian fiscal regime.

Lastly, we estimate the marginal responses of the primary government balance to unit changes in the lagged public debt ratio, using the rolling window approach. Previously, we started with the following fiscal reaction function estimated for each country *i* of our sample, following Bohn (1998):

$$s_{i,t} = \alpha_0 + \alpha_1 b_{i,t-4} + \mu_{i,t} \quad (6)$$

CCEMG estimator is a simple average of the individual common correlated effects estimators, and the estimates are obtained as averages of the individual estimates (Pesaran, 2006). This procedure allows to accommodate the possibility that the coefficients are not the same for all cross-section units.

where s_{it} is the primary government balance-to-GDP ratio in country i in quarter t; b_{it-4} corresponds to the stock of the public debt-to-GDP ratio lagged by four periods in country i; and μ_{it} is the random disturbance term of country i in quarter t.

Next, we use the computed rolling windows estimates as dependent variables and identify explanatory factors for these marginal responses.[2] The equations that identify the explanatory factors of the rolling windows fiscal sustainability coefficients are estimated using WLS (Weighted Least Squares) with fixed effects and Driscoll-Kraay (1998) robust standard errors. This is a non-parametric technique that assumes the error structure is heteroskedastic, autocorrelated up to some lag, and possibly correlated between the groups.

4. Data

The sample of this study consists of the 19 Eurozone countries, namely: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain, using quarterly data between 1999 and 2020.

We consider the series of government revenues (REV), government expenditures (EXP), primary government balance (PGB), public debt (d) and the output gap (OUTGAP), as a percentage of GDP. The country stocks of real public debt (PD) results from the stocks of nominal public debt adjusted by the GDP deflators. The primary government balance was calculated as the difference between the overall budget balance and the interest paid to service the public debt. The country output gaps were estimated through the Hodrick-Prescott (HP) filter, with a smoothing parameter of 1,600, using the real GDP data adjusted for seasonality and calendar effects.[3] These variables were obtained or calculated based on Eurostat data.

In order to obtain a comparable annual metric of the data, we calculate moving sums of four quarters for the quarterly government revenues, government expenditures, primary government balance, and the nominal GDP series. Hence, we compute the shares of government revenues, government expenditures and primary government balance on GDP for each observation, dividing the moving sums of these variables by the moving sum of the four quarters of nominal GDP. On the other hand, government debt data are already the respective stock at the end of each quarter.

[2] The rolling window method allows estimating models with time-varying parameters, in which the weights of historical data are treated equally.

[3] The output gap is defined as the difference between the actual output of an economy and its potential output, expressed as a percentage of potential GDP.

In addition, we estimate the rolling windows coefficients of the response of the primary government balance to a unit change in the public debt ratio lagged by four periods (PGB-RW), both variables as a percentage of GDP. Beyond the lagged public debt-to-GDP ratio and the output gap, the other explanatory variables of these marginal responses are as follows: the differential between the implicit interest rate of the nominal stock of public debt and the nominal growth rate of GDP (i-g); a fiscal rules index (FR); a dummy variable that takes the value 1 from 2010 (D2010); a dummy that assumes the value 1 if legislative elections took place in the year to which the quarter refers (DELECT); and average value of the sovereign ratings assigned by Moody's, Standard and Poor's and Fitch on a quantitative 17 and 21 level scale (RATING-A and RATING-B, respectively). The (i-g) differential was calculated based on Eurostat data. The fiscal rules index is obtained from the European Commission website. The political dummy variable was built based on the Database of Political Institutions 2020. The variables associated with the ratings were calculated based on data from the rating agencies.

Table 1 reports summary statistics for the fiscal variables by country and Table 2 presents the usual descriptive statistics for the variables used in the panel analysis. We also performed unit root tests of the series of government revenues and expenditures, primary government balance and government debt, as a percentage of GDP, by country. The results are shown in Tables A1-A4 in the Appendix.[4] Finally, Table A5, also in the Appendix, is the correlation matrix between the variables considered in panel analysis.

[4] In addition, we performed Pesaran (2004) cross-sectional dependence test and Pesaran (2007) panel unit root test for the series of government revenues and expenditures, primary government balance and public debt, as a percentage of GDP. The obtained findings suggest the existence of cross-sectional dependence and non-stationarity in panel of the variables under study. These results are available upon request.

Table 1: Descriptive Statistics, by country, fiscal variables (% of GDP)

	Government Revenues					Government Expenditures				
Country	**Obs.**	**Mean**	**Std. Dev.**	**Max.**	**Min.**	**Obs.**	**Mean**	**Std. Dev.**	**Max.**	**Min.**
Austria	77	0.490	0.007	0.507	0.475	77	0.511	0.017	0.571	0.486
Belgium	85	0.503	0.012	0.531	0.484	85	0.524	0.027	0.592	0.483
Cyprus	81	0.372	0.024	0.412	0.322	81	0.400	0.035	0.517	0.344
Estonia	73	0.383	0.020	0.443	0.348	73	0.381	0.033	0.459	0.329
Finland	85	0.527	0.010	0.548	0.512	85	0.520	0.036	0.573	0.465
France	85	0.512	0.015	0.536	0.491	85	0.550	0.023	0.616	0.514
Germany	73	0.447	0.009	0.468	0.434	73	0.457	0.018	0.508	0.434
Greece	85	0.438	0.044	0.514	0.380	85	0.502	0.045	0.629	0.451
Ireland	73	0.314	0.041	0.364	0.224	73	0.361	0.094	0.649	0.239
Italy	85	0.457	0.016	0.486	0.429	85	0.488	0.020	0.571	0.465
Latvia	85	0.359	0.020	0.390	0.317	85	0.382	0.032	0.458	0.337
Lithuania	85	0.343	0.012	0.380	0.322	85	0.367	0.033	0.450	0.331
Luxembourg	73	0.426	0.011	0.462	0.411	73	0.415	0.020	0.472	0.374
Malta	81	0.376	0.013	0.398	0.344	81	0.403	0.027	0.459	0.343
Netherlands	85	0.429	0.008	0.440	0.411	85	0.443	0.020	0.485	0.420
Portugal	85	0.416	0.017	0.451	0.389	85	0.465	0.029	0.526	0.424
Slovakia	85	0.379	0.023	0.432	0.341	85	0.422	0.037	0.538	0.362
Slovenia	85	0.444	0.007	0.459	0.433	85	0.478	0.034	0.603	0.433
Spain	85	0.384	0.014	0.415	0.350	85	0.422	0.036	0.524	0.381
	Primary Government Balance					**Government Debt**				
Country	**Obs.**	**Mean**	**Std. Dev.**	**Max.**	**Min.**	**Obs.**	**Mean**	**Std. Dev.**	**Max.**	**Min.**
Austria	77	0.005	0.016	0.029	-0.070	84	0.759	0.064	0.859	0.650
Belgium	85	0.019	0.029	0.069	-0.071	86	1.043	0.067	1.206	0.873
Cyprus	81	0.000	0.033	0.063	-0.094	84	0.763	0.219	1.160	0.453
Estonia	73	0.003	0.019	0.031	-0.056	84	0.074	0.032	0.191	0.034
Finland	85	0.022	0.037	0.096	-0.048	84	0.486	0.109	0.695	0.287
France	85	-0.013	0.019	0.021	-0.078	84	0.813	0.167	1.154	0.579
Germany	73	0.011	0.017	0.031	-0.037	84	0.682	0.071	0.820	0.577
Greece	85	-0.016	0.040	0.043	-0.117	84	1.412	0.356	2.057	0.999
Ireland	73	-0.025	0.072	0.038	-0.293	84	0.615	0.319	1.246	0.236
Italy	85	0.015	0.016	0.049	-0.061	84	1.216	0.137	1.556	1.039
Latvia	85	-0.013	0.023	0.013	-0.081	84	0.280	0.142	0.477	0.082
Lithuania	85	-0.011	0.027	0.022	-0.079	84	0.295	0.097	0.466	0.134
Luxembourg	73	0.014	0.017	0.048	-0.033	84	0.153	0.068	0.268	0.068
Malta	81	0.002	0.026	0.052	-0.084	81	0.615	0.084	0.713	0.407
Netherlands	85	0.005	0.022	0.045	-0.040	84	0.556	0.072	0.689	0.430
Portugal	85	-0.014	0.027	0.034	-0.085	84	0.968	0.306	1.352	0.540
Slovakia	85	-0.023	0.023	0.007	-0.086	84	0.455	0.090	0.602	0.266
Slovenia	85	-0.013	0.030	0.028	-0.120	85	0.470	0.230	0.839	0.218
Spain	85	-0.014	0.041	0.042	-0.098	86	0.699	0.254	1.200	0.350

Table 2: Descriptive Statistics, Panel Analysis

Variable	Obs.	Mean	Std. Dev.	Max.	Min.
REV	1551	0.422	0.061	0.548	0.224
EXP	1551	0.448	0.067	0.649	0.239
PGB	1551	-0.003	0.034	0.096	-0.293
d	1598	0.651	0.382	2.057	0.034
OUTGAP	1668	-0.000	0.027	0.136	-0.175
PGB-RW	1216	-0.018	3.155	10.017	-10.235
i-g	1555	-0.001	0.026	0.177	-0.255
FR	1672	0.303	0.983	2.885	-0.999
RATING-A	900	14.744	3.221	17	1
RATING-B	899	18.754	3.214	21	4

5. Analysis and discussion of results

5.1. Country-by-country Analysis

Table 3 shows the results of unit roots tests for the series in first differences of the stock of real government debt for Eurozone countries between 1999Q1 and 2020Q4. Considering the results of the ADF, PP and Ng and Perron (2001) tests for Belgium, Ireland, Malta and Portugal, only the PP test points to the rejection of the null hypothesis of non-stationarity. For Finland and Italy, the ADF and PP tests suggest the rejection of the null hypothesis of non-stationarity, although Ng and Perron (2001) tests do not. For the remaining countries, the null hypothesis of the existence of a unit root is rejected by the ADF, PP and Ng and Perron (2001) tests. Regarding the results of Vogelsang and Perron (1998) tests, and for all countries, the series in first differences of the stock of real government debt is stationary with breaks.

Observing the dates of the quarters corresponding to breaks, we can see that these mostly occur in quarters close to the outbreak of the global financial crisis in 2008 and the Eurozone crisis in 2010. In summary, analysing the results of the implemented unit root tests, we conclude, based on Trehan and Walsh (1991), that the solvency condition for individual Eurozone countries is satisfied, and, therefore, their public finances are sustainable.

Table 3: Unit root tests, First-Differenced Real Government Debt

Country	ADF	PP	Ng-Perron				VP(AO)	VP(IO)
			MZa	MZt	MSB	MPT		
Austria	-8.930***	-13.593***	-39.055***	-4.375***	0.112***	2.570***	2007Q4***	2007Q4***
Belgium	-2.687	-18.126***	-2.052	-0.973	0.474	42.087	N/A	2002Q4***
Cyprus	-8.144***	-8.298***	-75.605***	-6.135***	0.081***	1.262***	2009Q1***	2020Q1***
Estonia	0.332	-9.316***	-18.150**	-3.003**	0.165**	5.078**	2016Q1***	2020Q1***
Finland	-12.358***	-12.358***	-4.995	-1.565	0.313	18.167	2008Q3***	2008Q3***
France	-3.466*	-7.236***	-23.396**	-3.280**	0.140***	4.734**	2003Q2***	2003Q2***
Germany	-7.237***	-7.223***	-39.127***	-4.411***	0.113***	2.394***	2010Q4***	2010Q4***
Greece	-10.920***	-10.917***	-39.822***	-4.448***	0.112***	2.366***	2015Q1***	2012Q1***
Ireland	-2.031	-7.048***	-2.574	-0.928	0.360	28.410	2013Q1***	2013Q1***
Italy	-3.476**	-12.802***	-3.181	-1.171	0.368	26.686	2020Q3***	2020Q4***
Latvia	-8.384***	-8.693***	-40.775***	-4.471***	0.110***	2.470***	2010Q1***	2010Q1***
Lithuania	-9.416***	-9.412***	-40.908***	-4.522***	0.111***	2.229***	2017Q4***	2020Q1***
Luxembourg	-11.586***	-11.929***	-38.876***	-4.334***	0.112***	2.745***	2008Q4***	2013Q3***
Malta	-2.228	-9.492***	-6.808	-1.787	0.262	13.444	2018Q2***	2014Q4***
Netherlands	-7.855***	-7.853***	-38.497***	-4.361***	0.113***	2.510***	2008Q4***	2008Q4***
Portugal	-2.385	-8.531***	-4.275	-1.462	0.342	21.315	2011Q2***	2012Q2***
Slovakia	-8.050***	-8.051***	-37.487***	-4.328***	0.115***	2.441***	2008Q3***	2020Q1***
Slovenia	-8.690***	-8.863***	-41.398***	-4.550***	0.110***	2.202***	2014Q1***	2014Q1***
Spain	-5.479***	-5.382***	-33.438***	-4.071***	0.122***	2.828***	2008Q3***	2008Q3***

Notes: (a) ADF corresponds to the Augmented Dickey-Fuller test and PP is the Phillips-Perron test; (b) In Vogelsang–Perron (VP) test, "IO" means innovational outlier and "AO" means additive outlier; (c) The null hypothesis of ADF, PP, Ng-Perron and VP tests is the presence of unit root; (d) All tests are carried out with constant with linear time trend; (e) In ADF and VP tests, it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (f) In PP tests, the spectral estimation method is based on Bartlett kernel and bandwitch is automatically selected following Newey-West method; (g) In Ng-Perron tests, the spectral estimation method is AR-GLS detrended and it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (h) In VP tests, the break selection minimize Dickey-Fuller t-statistic; (i) Test statistics are reported; (j) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively; (k) N/A: Not Available.

According to Table 4, there is a cointegration relationship between government revenues and expenditures in the cases of Austria, Cyprus, Estonia, Finland, Lithuania, Luxembourg, Malta, Slovakia and Slovenia. Furthermore, there is a cointegration relationship between primary government balance and lagged government debt ratio for all countries, with exception of Italy and Slovakia.

Table 5 reports the results of country-by-country estimates of the relationship between government revenues and expenditures and the primary government balance and the lagged government debt ratio using the Stock and Watson (1993) method of long-run cointegration. On the one hand, there is deterministic cointegration between government revenues and expenditures for Austria, Belgium, Cyprus, Estonia, France, Germany, Ireland, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovenia, and Spain. Estimates of β are positive

and statistically significant, at least at a 5% significance level, for Belgium, Estonia, Finland, France, Italy, Luxembourg, Portugal, and Slovenia. These results allow us to conclude that, for these countries, there is sustainability of public finances and the prevalence of a Ricardian fiscal regime. On the other hand, there is a deterministic cointegration between the primary government balance and the lagged government debt ratio in the cases of Austria, Estonia, Finland, France, Ireland, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain. For Germany, Portugal, Slovakia and Slovenia, estimates of θ are positive and statistically significant, which suggests sustainability of public accounts and the occurrence of a Ricardian fiscal regime in these countries. Conversely, for Finland, France, Ireland, Malta, the Netherlands, and Spain, estimates of θ are negative and statistically significant. Nevertheless, we believe it is inappropriate to say that, for these countries, there is no fiscal sustainability, and the prevailing fiscal regime is non-Ricardian. These results probably confirm the "elusive character of fiscal sustainability" (Afonso and Jalles, 2016). As we concluded above, for Finland and France, there is a cointegration relationship between government revenues and expenditures, and therefore public finances are sustainable. Moreover, in the context of the EMU, the institutional framework, through the treaties and the mandate of the ECB, stipulates a regime of monetary predominance, with a view to ensuring price stability.

We also estimate fiscal reaction functions by country. Table A6, in the Appendix, presents the results of the estimations of fiscal reaction functions, according to Bohn (1998) and Canzoneri *et al.* (2001). With the exception of Estonia, Finland, France, Italy and Luxembourg, the fiscal authorities of the Eurozone countries manage public finances in accordance with the Ricardian regime. Furthermore, except for Cyprus, Estonia and France, past primary budget balances are typically used to reduce public debt-to-GDP ratios in the future. Combining the results, we can conclude that, in the context of the EMU, there is broad empirical evidence that corroborates both the backward-looking and forward-looking perspectives, generally supporting fiscal sustainability and rejecting the Fiscal Theory of the Price Level.

Table 4: Johansen–Juselius Cointegration Tests Results

	Revenues and Expenditures				Primary government balance and lagged government debt			
Country	**Trace**		**Maximum Eigenvalue**		**Trace**		**Maximum Eigenvalue**	
	r=0	**r ≤ 1**	**r=0**	**r ≤ 1**	**r=0**	**r ≤ 1**	**r=0**	**r ≤ 1**
Austria	19.233*	4.446*	14.788*	4.446*	31.078*	1.353	29.725*	1.353
Belgium	15.195	1.586	13.609	1.586	27.805*	1.758	26.046*	1.758
Cyprus	18.426*	7.441*	10.985	7.441*	26.794*	0.307	26.487*	0.307
Estonia	30.040*	2.576	27.464*	2.576	18.361*	0.062	18.299*	0.062
Finland	16.844*	1.060	15.784*	1.060	34.187*	0.076	34.111*	0.076
France	14.039	0.135	13.904	0.135	30.938*	1.004	29.934*	1.004
Germany	13.068	2.121	10.947	2.121	27.087*	3.140	23.948*	3.140
Greece	6.437	0.034	6.403	0.034	15.996*	0.140	15.857*	0.140
Ireland	10.378	0.038	10.340	0.038	37.827*	3.644	34.183*	3.644
Italy	10.342	0.734	9.608	0.734	6.661	1.549	5.112	1.549
Latvia	10.031	1.641	8.390	1.641	25.861*	0.865	24.996*	0.865
Lithuania	18.941*	4.928*	14.013	4.928	14.688	0.013	14.675*	0.013
Luxembourg	24.828*	3.099	21.729*	3.099	15.502*	1.385	14.116	1.385
Malta	14.320	4.812*	9.508	4.812*	23.965*	4.853*	19.112*	4.853*
Netherlands	12.039	1.467	10.572	1.467	33.732*	4.664*	29.068*	4.664*
Portugal	14.161	3.157	11.004	3.157	25.676*	0.530	25.146*	0.530
Slovakia	18.103*	1.857	16.246*	1.857	12.040	1.185	10.855	1.185
Slovenia	34.794*	7.979*	26.815*	7.979*	43.938*	0.029	43.910*	0.029
Spain	13.280	0.069	13.211	0.069	17.305*	0.398	16.907*	0.398

Note: *This symbol denotes rejection of the null hypothesis of no cointegration at the 5% level (based on MacKinnon–Haug–Michelis *p* values).

Table 5: Stock–Watson–Shin Estimates

	Revenues and Expenditures			Primary government balance and lagged government debt		
Country	β	C_μ	**R-squared**	θ	C_μ	**R-squared**
Austria	0.173	0.401**	0.211	-0.044	0.040*	0.632
	(0.354)	(0.181)		(0.028)	(0.021)	
Belgium	0.468***	0.258***	0.740	-0.029	0.045	0.518
	(0.063)	(0.033)		(0.085)	(0.088)	
Cyprus	0.268	0.268**	0.223	0.028	-0.013	0.658
	(0.287)	(0.116)		(0.019)	(0.015)	
Estonia	0.602***	0.155***	0.892	-0.219	0.022*	0.386
	(0.042)	(0.016)		(0.158)	(0.012)	
Finland	0.212***	0.417	0.583	-0.192***	0.118***	0.900
	(0.068)	(0.035)		(0.023)	(0.011)	
France	0.623***	0.171**	0.746	-0.044***	0.030***	0.852
	(0.120)	(0.066)		(0.012)	(0.010)	
Germany	-0.376	0.618**	0.518	0.070*	-0.036	0.740
	(0.587)	(0.267)		(0.035)	(0.025)	
Greece	0.668	0.101	0.456	0.049	-0.071	0.608
	(0.459)	(0.232)		(0.035)	(0.050)	
Ireland	0.297	0.209**	0.434	-0.104***	0.050***	0.787
	(0.209)	(0.080)		(0.020)	(0.014)	
Italy	1.047***	-0.054	0.836	0.007	0.008	0.276
	(0.134)	(0.065)		(0.015)	(0.018)	
Latvia	0.485	0.173	0.463	-0.004	-0.004	0.864
	(0.332)	(0.127)		(0.016)	(0.005)	
Lithuania	0.146	0.288***	0.523	0.050	-0.021	0.692
	(0.089)	(0.033)		(0.054)	(0.016)	
Luxembourg	0.581**	0.185*	0.564	0.050	0.008	0.246
	(0.252)	(0.104)		(0.054)	(0.010)	
Malta	0.096	0.339***	0.193	-0.140*	0.088*	0.705
	(0.109)	(0.044)		(0.081)	(0.052)	
Netherlands	0.128	0.371***	0.185	-0.127***	0.072***	0.711
	(0.191)	(0.085)		(0.039)	(0.022)	
Portugal	0.366**	0.246***	0.544	0.026***	-0.028***	0.733
	(0.160)	(0.075)		(0.008)	(0.009)	
Slovakia	0.537	0.153	0.373	0.095***	-0.061***	0.433
	(0.534)	(0.222)		(0.026)	(0.012)	
Slovenia	0.173***	0.362***	0.657	0.018***	-0.010***	0.889
	(0.042)	(0.020)		(0.007)	(0.003)	
Spain	-0.158	0.449***	0.385	-0.020*	0.013*	0.891
	(0.096)	(0.041)		(0.010)	(0.007)	

Notes: (a) The C_μ is the Shin (1994) LM statistic that tests for deterministic cointegration; (b) Standard errors in parentheses, adjusted for long-run variance; (c) The long-run variance of the cointegrating regression residuals was estimated using the Bartlett window with $l = 6 \approx INT(T^{1/2})$ as proposed by Newey and West (1987); (d) The number of leads and lags selected is $q = 4$; (e) *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

5.2. Panel Analysis

Table 6: Panel estimates of the relationship between government revenues and expenditures[5]

Regressors/Sample	Full Sample	Before 2010	After 2010	Government debt below 60% of GDP	Government debt between 60 and 90% of GDP	Government debt above 90% of GDP
REV_{it-4}	0.404***	0.181**	0.156	0.374***	0.662***	0.264*
	(0.057)	(0.087)	(0.124)	(0.093)	(0.090)	(0.142)
EXP_{it}	0.178***	0.159***	0.209***	0.185***	0.106*	0.086***
	(0.039)	(0.057)	(0.054)	(0.054)	(0.059)	(0.027)
$OUTGAP_{it}$	-0.063	0.024	-0.067	0.001	-0.054**	-0.256***
	(0.044)	(0.043)	(0.049)	(0.029)	(0.024)	(0.059)
Cross-section averaged regressors for:						
REV_{it}	0.973***	0.623*	0.823***	0.905***	0.834**	0.684***
	(0.195)	(0.324)	(0.235)	(0.285)	(0.381)	(0.152)
REV_{it-4}	-0.295*	0.034	-0.133	-0.368**	-0.627*	-0.419***
	(0.154)	(0.233)	(0.243)	(0.146)	(0.377)	(0.037)
EXP_{it}	-0.174***	-0.160*	-0.141	-0.181	-0.150**	-0.066
	(0.052)	(0.083)	(0.099)	(0.114)	(0.074)	(0.116)
$OUTGAP_{it}$	0.074	0.009	0.083	0.012	0.049	0.273***
	(0.060)	(0.071)	(0.066)	(0.054)	(0.099)	(0.079)
Obs.	1,475	639	760	624	527	324
N.o of countries	19	19	19	8	7	4
Wald	73.100	12.510	18.200	28.000	62.780	32.490
p-value	0.000	0.006	0.000	0.000	0.000	0.000
RMSE	0.007	0.004	0.005	0.007	0.007	0.006

Notes: (a) The dependent variable is the government revenues as a percentage of GDP; (b) All coefficients represent averages across groups (countries); (c) Coefficient averages computed as outlier-robust means, using robust regression; (d) Standard errors in brackets; (e) Constant term estimated, but omitted for reasons of parsimony; (f) *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Table 6 shows that, for the Eurozone as a whole, government expenditures have a positive and highly significant effect on government revenues. After 2010, the effect is greater than before 2010, which can be linked to the need of consolidation in the aftermath of the GFC. However, for higher average public debt-to-GDP ratios, estimates of government revenues responses to expenditures decline (last column in Table 6), likely due to increasing public debt

[5] Government debt below 60% of GDP: Estonia, Finland, Latvia, Lithuania, Luxembourg, Netherlands, Slovakia and Slovenia; Government debt between 60 and 90% of GDP: Austria, Cyprus, France, Germany, Ireland, Malta and Spain; Government debt above 90% of GDP: Belgium, Greece, Italy and Portugal.

service. The output gap has a negative and significant effect for countries whose average public debt-to-GDP ratio is greater than 60%, which suggests the counter-cyclicality of government revenues for higher levels of public debt. Government revenues are a highly persistent variable, given the sign and statistical significance of government revenues in the same quarter of the previous year.

Table 7: I Panel Fiscal Reaction Functions, primary government balance as a dependent variable

Regressors/Sample	Full Sample	Before 2010	After 2010	Government debt below 60% of GDP	Government debt between 60 and 90% of GDP	Government debt above 90% of GDP
PGB_{it-4}	0.288***	0.048	-0.218***	0.321***	0.346**	-0.084
	(0.078)	(0.060)	(0.082)	(0.056)	(0.140)	(0.095)
d_{it-4}	0.062***	0.101***	0.081**	0.017	0.063***	0.141***
	(0.023)	(0.039)	(0.041)	(0.020)	(0.023)	(0.018)
$OUTGAP_{it}$	0.076	-0.019	0.053	0.236***	0.181**	-0.225***
	(0.080)	(0.089)	(0.116)	(0.078)	(0.084)	(0.035)
Cross-section averaged regressors for:						
PGB_{it}	0.805***	0.774***	0.859***	1.071***	0.547***	0.767***
	(0.082)	(0.193)	(0.076)	(0.114)	(0.104)	(0.071)
PGB_{it-4}	-0.300***	0.409	-0.040	-0.292***	-0.138	0.020
	(0.082)	(0.324)	(0.132)	(0.110)	(0.107)	(0.359)
d_{it-4}	-0.051*	-0.010	-0.040***	-0.052	-0.037	-0.116
	(0.028)	(0.039)	(0.014)	(0.071)	(0.033)	(0.089)
$OUTGAP_{it}$	-0.062	0.021	-0.052	-0.227**	-0.053	0.235***
	(0.094)	(0.106)	(0.129)	(0.098)	(0.049)	(0.039)
Obs.	1,466	630	760	619	526	321
N.o of countries	19	19	19	8	7	4
Wald	21.66	7.54	11.28	42.59	18.18	101.03
p-value	0.000	0.057	0.010	0.000	0.000	0.000
RMSE	0.013	0.006	0.009	0.011	0.016	0.010

Notes: (a) The dependent variable is the primary government balance as a percentage of GDP; (b) All coefficients represent averages across groups (countries); (c) Coefficient averages computed as outlier-robust means, using robust regression; (d) Standard errors in brackets; (e) Constant term estimated, but omitted for reasons of parsimony; (f) *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

According to Table 7, the public debt ratio for the same quarter of the previous year has a positive and highly significant impact on the primary government balance, with a higher impact before 2010 than after that year. As expected, for higher public debt ratios, the primary government balance response is higher. The primary government balance is highly persistent

and positive for the sample as a whole and for countries whose average public debt ratio is less than or equal to 90% of GDP. Finally, for countries whose average public debt ratio is less than or equal to 90% of GDP, the output gap has a positive and significant impact on the primary budget balance. On the other hand, for countries whose average public debt ratio is above 90% of GDP, the output gap has a negative and highly significant impact.

Table 8: II Panel Fiscal Reaction Functions, government debt as a dependent variable

Regressors/Sample	Full Sample	Before 2010	After 2010	Government debt below 60% of GDP	Government debt between 60 and 90% of GDP	Government debt above 90% of GDP
d_{it-4}	0.691***	0.590***	0.324***	0.608***	0.728***	0.560***
	(0.046)	(0.079)	(0.084)	(0.014)	(0.070)	(0.138)
PGB_{it-4}	-0.374***	-0.522***	-0.030	-0.376	-0.431***	-0.053
	(0.141)	(0.112)	(0.142)	(0.252)	(0.119)	(0.433)
$OUTGAP_{it}$	-0.377***	-0.264*	-0.727***	-0.643***	-0.745***	-0.422***
	(0.067)	(0.146)	(0.181)	(0.076)	(0.242)	(0.153)
Cross-section averaged regressors for:						
d_{it}	0.937***	0.787***	0.964***	1.059***	0.865***	0.746***
	(0.104)	(0.135)	(0.129)	(0.147)	(0.189)	(0.105)
d_{it-4}	-0.664***	-0.700***	-0.359***	-0.769***	-0.654***	-0.533***
	(0.103)	(0.153)	(0.108)	(0.133)	(0.143)	(0.102)
PGB_{it-4}	0.387*	-0.142	0.206	0.621**	0.802	-0.051
	(0.206)	(0.452)	(0.330)	(0.300)	(0.490)	(0.352)
$OUTGAP_{it}$	0.464***	0.270	0.611***	0.466*	0.739***	0.377
	(0.172)	(0.226)	(0.238)	(0.254)	(0.244)	(0.456)
Obs.	1,466	630	760	619	526	321
N.o of countries	19	19	19	8	7	4
Wald	263.68	80.88	31.18	1995.04	130.15	24.14
p-value	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	0.027	0.013	0.021	0.020	0.027	0.024

Notes: (a) The dependent variable is the government debt as a percentage of GDP; (b) All coefficients represent averages across groups (countries); (c) Coefficient averages computed as outlier-robust means, using robust regression; (d) Standard errors in brackets; (e) Constant term estimated, but omitted for reasons of parsimony; (f) *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Analysing Table 8, we conclude that the primary government balance for the same quarter of the previous year has a negative and highly significant impact on the public debt ratio for Eurozone as a whole. This effect is more pronounced before 2010 and after 2010 it becomes non-significant, which can imply that debt ratios changed beyond the standard arithmetic of deficits and debt. Only for countries whose average public debt ratio is between 60 and 90% of

GDP the effect is significant (at a 1% significance level). The public debt ratio is highly persistent, and the output gap translates into a reduction in the public debt ratio.

Table 9: Determinants of rolling windows fiscal sustainability coefficients, 2005Q1-2020Q4, Baseline Estimates

Regressors/Specification	(1)	(2)	(3)	(4)	(5)	(6)
$PGB\text{-}RW_{it-4}$	0.778***	0.777***	0.738***	0.740***	0.734***	0.733***
	(0.059)	(0.058)	(0.052)	(0.052)	(0.053)	(0.053)
d_{it-4}	0.770	0.005	1.770*	1.793*	3.302***	3.242***
	(0.923)	(1.100)	(0.948)	(0.950)	(1.048)	(1.034)
$OUTGAP_{it}$	0.320	0.201	-3.269	-2.914	-4.097	-4.149
	(3.642)	(3.636)	(2.448)	(2.414)	(2.436)	(2.418)
$(i\text{-}g)_{it}$	4.894	5.019	3.761	3.817	4.283	4.252
	(3.774)	(3.817)	(3.022)	(2.979)	(3.519)	(3.510)
FR_{it}		0.249	0.517***	0.509***	0.497***	0.497***
		(0.163)	(0.152)	(0.152)	(0.158)	(0.157)
$D2010_{it}$			-1.693***	-1.686***	-1.693***	-1.695***
			(0.217)	(0.217)	(0.243)	(0.242)
$DELECT_{it}$				-0.189*	-0.200*	-0.198*
				(0.106)	(0.102)	(0.101)
$RATING\text{-}A_{it}$					0.152***	
					(0.050)	
$RATING\text{-}B_{it}$						0.144***
						(0.046)
Observations	1,140	1,140	1,140	1,136	1,117	1,117
R-squared	0.637	0.642	0.689	0.690	0.694	0.694
Number of groups	19	19	19	19	19	19

Notes: (a) WLS (Weighted Least Squares) with fixed effects and Driscoll-Kraay errors Estimates. The weights are given by the inverse of the standard errors of the estimated rolling windows coefficients; (b) The dependent variable is the response of the primary government balance to a unit change in public debt lagged by a four periods, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) * and *** denote statistical significance at the 10% and 1% level, respectively.

Table 9 reports the estimates of the determinants of the response of the primary government balance to the change in the lagged public debt ratio, corresponding to the same quarter of the previous year. We can conclude that the dependent variable is highly persistent. The higher the public debt ratio corresponding to the same quarter of the previous year, the higher the fiscal sustainability coefficient, especially after the introduction of the variables associated with the ratings. The fiscal rules index has a positive and highly significant impact on the sustainability of public finances. At the same time, from the first quarter of 2010 onwards, the sustainability of public finances appears to be strongly weakened. The holding of legislative elections deteriorates fiscal sustainability, albeit only at 10% significance level. Higher sovereign ratings assigned by rating agencies also improve the sustainability of public

finances. This result can be explained by the fact that higher rating levels translate into lower sovereign bond yields and, consequently, lower public debt service. This contributes to a greater capacity of governments to ensure fiscal sustainability. Lastly, the output gap and the differential between the implicit interest rate on the stock of public debt and the GDP growth rate have the expected signs (in the case of the output gap in specifications (3)-(6)), although non-significant.

Table 10: Determinants of rolling windows fiscal sustainability coefficients, 2005Q1-2020Q4, Robustness Checks Estimates

Sub-Sample	Government debt below 60% of GDP		Government debt above 60% of GDP		Before 2010		After 2010	
Regressors/Specification	(I.1)	(I.2)	(II.1)	(II.2)	(III.1)	(III.2)	(IV.1)	(IV.2)
$PGB\text{-}RW_{it-4}$	0.777***	0.777***	0.637***	0.636***	0.419***	0.419***	0.783***	0.786***
	(0.065)	(0.065)	(0.074)	(0.074)	(0.067)	(0.067)	(0.032)	(0.031)
d_{it-4}	1.220	1.220	4.039***	3.941***	-1.034	-1.034	4.637***	4.512***
	(2.111)	(2.111)	(1.046)	(1.023)	(6.991)	(6.991)	(0.621)	(0.617)
$OUTGAP_{it}$	-5.534	-5.534	-2.113	-2.286	-8.365***	-8.365***	-0.484	-0.557
	(3.240)	(3.240)	(2.581)	(2.571)	(1.242)	(1.242)	(1.528)	(1.524)
$(i\text{-}g)_{it}$	7.277*	7.277*	2.289	2.199	10.869**	10.869**	0.823	0.814
	(3.366)	(3.366)	(2.861)	(2.843)	(4.925)	(4.925)	(1.278)	(1.267)
FR_{it}	0.712***	0.712***	0.397	0.393	2.201**	2.201**	0.265*	0.268*
	(0.158)	(0.158)	(0.231)	(0.227)	(0.886)	(0.886)	(0.150)	(0.149)
$D2010_{it}$	-1.629***	-1.629***	-1.589***	-1.597***				
	(0.238)	(0.238)	(0.337)	(0.338)				
$DELECT_{it}$	-0.414**	-0.414**	-0.048	-0.043	-0.137	-0.137	-0.208*	-0.203*
	(0.170)	(0.170)	(0.146)	(0.146)	(0.289)	(0.289)	(0.101)	(0.099)
$RATING\text{-}A_{it}$	0.089		0.189**		-0.104		0.213***	
	(0.160)		(0.065)		(0.287)		(0.066)	
$RATING\text{-}B_{it}$		0.089		0.176**		-0.104		0.194***
		(0.160)		(0.057)		(0.287)		(0.059)
Observations	468	468	649	649	304	304	737	737
R-squared	0.787	0.787	0.583	0.582	0.266	0.266	0.794	0.793
Number of groups	8	8	11	11	19	19	19	19

Notes: (a) WLS (Weighted Least Squares) with fixed effects and Driscoll-Kraay errors Estimates. The weights are given by the inverse of the standard errors of the estimated rolling windows coefficients; (b) The dependent variable is the response of the primary government balance to a unit change in public debt lagged by a four periods, both variables as a percentage of GDP; (c) Robust standard errors in brackets; (d) Constant term estimated, but omitted for reasons of parsimony; (e) *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

Then, in order to test the robustness of the baseline results found, we divided the sample according to two criteria, namely: (i) whether the average public debt-to-GDP ratio of the

country is below or above 60%; and (ii) before and after 2010. Based on Table 10, and on the several sub-samples considered, the variable that measures fiscal sustainability is highly persistent, with lower estimates in the sub-sample before 2010. The public debt-to-GDP ratio for the same quarter of the previous year has a positive sign and it is highly significant for countries whose average public debt-to-GDP ratio is above 60% and after 2010. The output gap has a negative and highly significant effect before 2010. The (i-g) differential exhibits a positive sign only for countries whose average public debt-to-GDP ratio is below 60% and before 2010. The fiscal rules index has a positive impact for countries whose average public debt-to-GDP ratio is below 60%, before and after 2010. As of the first quarter of 2010, we find a reduction in fiscal sustainability, a result found in Table 9. The occurrence of legislative elections has a negative effect on countries whose average public debt-to-GDP ratio is less than 60% and after 2010. Only for countries whose average public debt-to-GDP ratio is greater than 60% and after 2010, the variables associated with the ratings show a positive sign and are highly significant.

6. Conclusions

In this paper, we have studied the issue of public finances' solvency for the 19 Eurozone countries, with quarterly data between 1999Q1 and 2020Q4. The analysis is carried out in a country-by-country perspective as well as in a panel framework.

By studying the series in first differences of the stock of real public debt, we conclude that public finances are sustainable in all EMU countries. Combining the results of the Johansen-Juselius cointegration test with the Stock-Watson-Shin estimates, both relating to the relationship between government revenues and expenditures and between the primary government balance and the lagged public debt ratio, we find that there is diversity at the level of empirical evidence. In this context, the relationships tested and the methodologies used should be interpreted as complementary and not as alternatives. Furthermore, the fiscal reaction functions estimated by individual country suggest the existence of a Ricardian fiscal regime in most Eurozone economies.

In the panel analysis, we examine the relationship between government revenues and expenditures and estimate fiscal reaction functions of the relationship between the primary government balance and the lagged public debt ratio and between the public debt ratio and the lagged primary government balance. The results found are as follows, namely: (i) the response of revenues to government expenditures is higher after 2010 and is decreasing towards higher levels of the average public debt ratio; (ii) the response of the primary government balance to the lagged public debt ratio is lower after 2010 and increases towards higher levels of the

average public debt ratio; and (iii) the lagged primary government balance results in a reduction in the public debt ratio, especially before 2010 and only in countries whose average public debt ratio is between 60 and 90% of GDP. From these results, we can conclude on the sustainability of public finances in the Eurozone as a whole and on the prevalence of a Ricardian fiscal regime, contradicting the Fiscal Theory of the Price Level.

A novel aspect of the article is the estimation of country-specific rolling windows coefficients of the response of the primary government balance to the lagged public debt ratio (both expressed as a percentage of GDP). Then, we use the estimates obtained to assess the importance of a set of determinants for the sustainability of public finances. In this respect, the lagged public debt ratio, the fiscal rules index and the sovereign ratings have a positive impact on fiscal sustainability. As of 2010 and when legislative elections were held, the effect was negative. Through a sensitivity analysis, we found that the lagged public debt ratio and the ratings have a positive impact only in countries whose average public debt ratio is above 60% of GDP and after 2010. The differential between the implicit interest rate of the stock of public debt and the nominal GDP growth rate has a positive effect only for countries whose average public debt ratio is less than 60% of GDP and before 2010. This evidence points to a greater importance of the assigned financial ratings countries from 2010 and also for countries with higher public debt ratios. Consequently, the interest rates mechanism was replaced by the signalling role of ratings, which themselves influence the interest rates prevailing in the sovereign debt bond markets.

Appendix

Table A1: Unit root tests, Government Revenues (% GDP)

Country	ADF	PP	Ng-Perron				VP(AO)	VP(IO)
			MZa	MZt	MSB	MPT		
Austria	-2.569	-2.676	-3.172	-1.251	0.394	28.539	2012Q1	2012Q1
Belgium	-1.154	-1.731	-5.335	-1.572	0.295	16.877	2011Q1	2011Q1
Cyprus	-2.190	-2.370	-8.787	-2.072	0.236	10.459	2005Q4	2006Q1
Estonia	-2.006	-2.455	-9.908	-2.226	0.225	9.197	2011Q1	2012Q1
Finland	-1.345	-1.693	-4.219	-1.399	0.332	21.072	2019Q2	2019Q3
France	-2.431	-2.221	-3.630	-1.345	0.371	25.069	2012Q2	2012Q3
Germany	-3.842**	-2.065	-19.064**	-3.052**	0.160**	5.000**	2009Q1*	2010Q2
Greece	-2.245	-1.968	-6.400	-1.788	0.279	14.239	2011Q1	2011Q3
Ireland	-1.718	-1.588	-3.085	-1.073	0.348	25.669	2014Q2	2014Q4
Italy	-2.960	-2.525	-7.489	-1.932	0.258	12.174	2011Q2	2012Q1
Latvia	-3.685**	-3.726**	-3.210	-1.240	0.386	27.801	2000Q2	2010Q3**
Lithuania	-4.313***	-3.078	-1.262	-0.632	0.501	50.995	2011Q2	2011Q2**
Luxembourg	-2.356	-2.270	-14.524*	-2.674*	0.184*	6.398*	2018Q2	2014Q2
Malta	-2.167	-2.156	-3.752	-1.234	0.329	22.413	2004Q3*	2004Q3*
Netherlands	-2.879	-3.291*	-4.810	-1.513	0.315	18.725	2005Q2	2004Q2
Portugal	-2.179	-2.324	-8.808	-2.091	0.237	10.373	2011Q2	2013Q1
Slovakia	-3.017	-2.160	-5.217	-1.572	0.301	17.299	2012Q3	2012Q4
Slovenia	-1.407	-1.691	-4.749	-1.432	0.302	18.525	2011Q4	2011Q4
Spain	-2.087	-1.797	-14.656*	-2.585	0.176*	6.931	2008Q1	2008Q1*

Notes: (a) ADF corresponds to the Augmented Dickey-Fuller test and PP is the Phillips-Perron test; (b) In Vogelsang–Perron (VP) test, "IO" means innovational outlier and "AO" means additive outlier; (c) The null hypothesis of ADF, PP, Ng-Perron and VP tests is the presence of unit root; (d) All tests are carried out with constant with linear time trend; (e) In ADF and VP tests, it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (f) In PP tests, the spectral estimation method is based on Bartlett kernel and bandwitch is automatically selected following Newey-West method; (g) In Ng-Perron tests, the spectral estimation method is AR-GLS detrended and it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (h) In VP tests, the break selection minimize Dickey-Fuller t-statistic; (i) Test statistics are reported; (j) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Table A2: Unit root tests, Government Expenditures (% GDP)

Country	ADF	PP	Ng-Perron				VP(AO)	VP(IO)
			MZa	MZt	MSB	MPT		
Austria	-2.336	-1.919	-529.851***	-16.202***	0.031***	0.301***	2017Q3	2008Q3
Belgium	-1.910	-1.880	-12.887	-2.408	0.187	7.796	2008Q2	2011Q1
Cyprus	-2.220	-3.113	-7.054	-1.867	0.264	12.936	2012Q2	2015Q4
Estonia	-3.274*	-2.181	-38.967***	-4.357***	0.112***	2.647***	2011Q2	2012Q1
Finland	-3.340*	-2.438	-23.497**	-3.415**	0.145**	3.953***	2008Q2	2011Q1
France	-3.586**	-2.224	-175.020***	-9.281***	0.053***	0.737***	2008Q1	2008Q1
Germany	-1.945	-0.754	-139.964***	-8.210***	0.059***	1.152***	2019Q3	2020Q1
Greece	-1.735	-2.065	-8.918	-2.036	0.228	10.506	2016Q1	2008Q1
Ireland	-1.718	-1.467	-5.839	-1.689	0.289	15.576	2013Q3	2009Q4
Italy	-1.887	-1.631	-69.475***	-5.640***	0.081***	2.409***	2017Q3	2007Q4
Latvia	-2.835	-2.322	-16.720*	-2.848*	0.170*	5.712*	2007Q2	2008Q1
Lithuania	-1.315	-1.568	-7.545	-1.746	0.231	12.509	2010Q3	2011Q4
Luxembourg	-1.564	-0.906	-12.300	-2.248	0.183*	8.638	2018Q3	2018Q4
Malta	-2.323	-1.259	-6.363	-1.445	0.227	14.321	2016Q1	2019Q3
Netherlands	-2.814	-1.808	-124.640***	-7.869***	0.063***	0.819***	2008Q1	2008Q3
Portugal	-1.642	-1.889	-4.322	-1.467	0.339	21.054	2014Q3	2013Q1
Slovakia	-3.912**	-1.796	-14.094	-2.566	0.182*	6.983	2008Q3*	2008Q4**
Slovenia	-1.871	-2.228	-7.155	-1.856	0.259	12.795	2011Q1	2008Q3
Spain	-2.099	-1.542	-113.955***	-7.482***	0.066***	1.038***	2007Q1	2007Q3

Notes: (a) ADF corresponds to the Augmented Dickey-Fuller test and PP is the Phillips-Perron test; (b) In Vogelsang–Perron (VP) test, "IO" means innovational outlier and "AO" means additive outlier; (c) The null hypothesis of ADF, PP, Ng-Perron and VP tests is the presence of unit root; (d) All tests are carried out with constant with linear time trend; (e) In ADF and VP tests, it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (f) In PP tests, the spectral estimation method is based on Bartlett kernel and bandwitch is automatically selected following Newey-West method; (g) In Ng-Perron tests, the spectral estimation method is AR-GLS detrended and it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (h) In VP tests, the break selection minimize Dickey-Fuller t-statistic; (i) Test statistics are reported; (j) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Table A3: Unit Root tests, Primary Government Balance (% GDP)

Country	ADF	PP	Ng-Perron				VP(AO)	VP(IO)
			MZa	MZt	MSB	MPT		
Austria	-1.568	-1.735	1.769	0.358	0.202	9.912	2020Q1	2020Q3
Belgium	0.462	-0.283	3.314	1.680	0.507	31.281	2004Q4	2008Q2
Cyprus	-2.615*	-2.918**	-12.044**	-2.384**	0.198**	2.309**	2013Q3*	2014Q1
Estonia	-1.785	-1.680	-14.849***	-2.357**	0.159***	2.974**	2007Q3	2007Q4
Finland	-1.054	-0.878	-0.270	-0.118	0.438	15.592	2008Q3**	2008Q2**
France	-1.448	-0.896	-27.307***	-3.305***	0.121***	2.100**	2008Q1	2020Q1
Germany	-2.685*	-1.838	-45.635***	-4.708***	0.103***	0.720***	2010Q1	2020Q1
Greece	-1.842	-2.154	-4.158	-1.246	0.300	6.152	2011Q2	2013Q2
Ireland	-2.162	-1.783	-12.608**	-2.502**	0.198**	1.978**	2007Q4	2010Q4
Italy	-1.147	-0.747	-8.558**	-1.349	0.158***	5.194	2020Q1	2020Q1
Latvia	-2.335	-2.103	-12.822**	-2.519**	0.196**	1.964**	2008Q4	2010Q3
Lithuania	-1.928	-1.613	-36.357***	-4.162***	0.114***	0.970***	2010Q3	2011Q4
Luxembourg	-3.516**	-2.108	-118.876***	-7.551***	0.064***	0.479***	2017Q4*	2013Q1
Malta	-3.005**	-1.348	-79.267***	-6.166***	0.078***	0.579***	2007Q1	2007Q1
Netherlands	-1.958	-1.915	-7.381*	-1.696*	0.230**	4.113*	2019Q4	2008Q3
Portugal	-1.738	-2.156	-5.191	-1.564	0.301	4.847	2013Q4	2014Q4
Slovakia	-3.407**	-2.202	-5.130	-1.587	0.309	4.814	2010Q1	2010Q4
Slovenia	-2.006	-2.365	-8.448**	-1.901*	0.225**	3.478*	2011Q1***	2013Q4*
Spain	-1.994	-1.346	-33.444***	-3.960***	0.118***	1.119***	2007Q1	2007Q3

Notes: (a) ADF corresponds to the Augmented Dickey-Fuller test and PP is the Phillips-Perron test; (b) In Vogelsang–Perron (VP) test, "IO" means innovational outlier and "AO" means additive outlier; (c) The null hypothesis of ADF, PP, Ng-Perron and VP tests is the presence of unit root; (d) All tests are carried out with constant without linear time trend; (e) In ADF and VP tests, it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (f) In PP tests, the spectral estimation method is based on Bartlett kernel and bandwitch is automatically selected following Newey-West method; (g) In Ng-Perron tests, the spectral estimation method is AR-GLS detrended and it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (h) In VP tests, the break selection minimize Dickey-Fuller t-statistic; (i) Test statistics are reported; (j) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Table A4: Unit Root tests, Government Debt (% GDP)

Country	ADF	PP	Ng-Perron				VP(AO)	VP(IO)
			MZa	MZt	MSB	MPT		
Austria	-2.738	-2.511	-12.882	-2.537	0.197	7.080	2009Q3*	2008Q3*
Belgium	-1.922	-2.417	-38.770***	-4.349***	0.112***	2.640***	2007Q3	2008Q3
Cyprus	-1.574	-1.720	-4.384	-1.440	0.328	20.432	2012Q4	2012Q1
Estonia	-1.319	-1.319	-6.482	-1.351	0.208	14.175	2007Q1	2007Q1
Finland	-2.088	-2.058	-2.694	-1.053	0.391	30.394	2009Q2	2009Q2
France	-3.256*	-2.227	-435.468***	-14.740***	0.034***	0.242***	2010Q1	2010Q4*
Germany	-1.319	-1.281	-3.320	-1.258	0.379	26.832	2008Q4	2010Q3
Greece	-2.172	-2.118	-5.738	-1.649	0.287	15.800	2008Q4	2008Q4
Ireland	-2.944	-1.059	-56.847***	-5.310***	0.093***	1.706***	2008Q4	2008Q1
Italy	-2.099	-1.936	-26.007***	-3.475***	0.134	4.274**	2010Q3	2008Q3
Latvia	-2.602	-1.810	-20.729**	-3.216**	0.155**	4.417**	2008Q2	2008Q3***
Lithuania	-1.630	-1.892	-3.368	-1.236	0.367	25.879	2009Q1	2009Q1
Luxembourg	-2.233	-2.099	-7.530	-1.940	0.258	12.102	2008Q1	2008Q3***
Malta	-1.904	-2.037	-2.664	-1.150	0.432	34.087	2009Q1	2009Q1
Netherlands	-1.443	-1.753	-2.404	-1.076	0.448	37.035	2016Q2	2008Q3
Portugal	-3.124	-1.426	-64.473***	-5.672***	0.088***	1.440***	2010Q4	2011Q1
Slovakia	-1.164	-1.347	-3.001	-1.132	0.377	28.018	2009Q1	2009Q1
Slovenia	-1.359	-1.692	-2.126	-1.029	0.484	42.788	2012Q3	2005Q1
Spain	-1.866	-1.696	-3.818	-1.279	0.335	22.507	2019Q2	2020Q2

Notes: (a) ADF corresponds to the Augmented Dickey-Fuller test and PP is the Phillips-Perron test; (b) In Vogelsang–Perron (VP) test, "IO" means innovational outlier and "AO" means additive outlier; (c) The null hypothesis of ADF, PP, Ng-Perron and VP tests is the presence of unit root; (d) All tests are carried out with constant with linear time trend; (e) In ADF and VP tests, it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (f) In PP tests, the spectral estimation method is based on Bartlett kernel and bandwitch is automatically selected following Newey-West method; (g) In Ng-Perron tests, the spectral estimation method is AR-GLS detrended and it is considered the lag length automatic based on Schwarz Information Criterion, with maxlag=12; (h) In VP tests, the break selection minimize Dickey-Fuller t-statistic; (i) Test statistics are reported; (j) *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Table A5: Correlation matrix, Panel Analysis

	REV	EXP	PGB	d	OUTGAP	PGB-RW	i-g	FR	D2010	DELECT	RATING-A	RATING-B
REV	1											
EXP	0.842	1										
PGB	0.244	-0.276	1									
d	0.384	0.555	-0.076	1								
OUTGAP	-0.018	-0.173	0.275	-0.092	1							
PGB-RW	0.020	-0.142	0.341	-0.033	0.008	1						
i-g	0.118	0.193	-0.105	0.153	-0.361	0.014	1					
FR	0.122	-0.042	0.186	0.133	-0.015	0.008	-0.054	1				
D2010	0.105	0.158	-0.190	0.320	-0.084	-0.241	-0.007	0.608	1			
DELECT	0.004	0.027	-0.047	0.017	0.090	-0.047	-0.018	0.002	0.012	1		
RATING-A	0.391	0.181	0.255	-0.462	0.104	0.102	0.000	-0.149	-0.311	0.008	1	
RATING-B	0.375	0.157	0.261	-0.474	0.093	0.100	-0.004	-0.137	-0.308	-0.005	1	1

Table A6: Fiscal Reaction Functions country-by-country

	Dependent variable: Primary government balance-to-GDP ratio (PGB)					Dependent variable: Government debt-to-GDP ratio (d)				
Country	**PGB_{it-4}**	**d_{it-4}**	**$OUTGAP_{it}$**	**Obs.**	**R-squared**	**d_{it-4}**	**PGB_{it-4}**	**$OUTGAP_{it}$**	**Obs.**	**R-squared**
Austria	0.278**	0.042*	0.376***	73	0.303	0.774***	-0.638**	-1.441***	73	0.795
	(0.130)	(0.021)	(0.112)			(0.051)	(0.303)	(0.282)		
Belgium	0.842***	0.082***	0.427***	81	0.738	0.727***	-0.468***	-1.355***	81	0.781
	(0.043)	(0.025)	(0.080)			(0.057)	(0.101)	(0.284)		
Cyprus	0.154	0.047***	0.401**	77	0.210	0.900***	0.029	-1.577***	77	0.865
	(0.120)	(0.016)	(0.159)			(0.039)	(0.342)	(0.427)		
Estonia	-0.066	-0.109	0.247***	69	0.304	0.983***	-0.085	-0.136***	69	0.565
	(0.154)	(0.085)	(0.073)			(0.091)	(0.097)	(0.050)		
Finland	0.885***	0.018	0.605***	80	0.844	0.826***	-0.760***	-1.065***	80	0.952
	(0.067)	(0.027)	(0.087)			(0.046)	(0.106)	(0.111)		
France	0.566***	-0.019	0.296***	80	0.556	1.006***	-0.115	-1.082***	80	0.956
	(0.083)	(0.012)	(0.066)			(0.034)	(0.202)	(0.229)		
Germany	0.557***	0.074***	0.376***	69	0.561	0.823***	-0.941***	-0.920***	69	0.818
	(0.073)	(0.021)	(0.073)			(0.049)	(0.250)	(0.167)		
Greece	0.474***	0.036***	0.133	80	0.398	1.011***	-0.890***	-0.289	80	0.936
	(0.106)	(0.009)	(0.122)			(0.026)	(0.273)	(0.419)		
Ireland	0.830***	0.060***	0.065	69	0.593	0.716***	-1.466***	-0.970***	69	0.967
	(0.160)	(0.015)	(0.098)			(0.027)	(0.124)	(0.199)		
Italy	0.423***	-0.014	0.241***	80	0.234	1.047***	-0.444*	-1.128***	80	0.929
	(0.070)	(0.013)	(0.043)			(0.039)	(0.229)	(0.281)		
Latvia	0.542***	0.044***	0.131**	80	0.521	0.871***	-0.630**	-0.522***	80	0.900
	(0.095)	(0.014)	(0.056)			(0.038)	(0.256)	(0.147)		
Lithuania	0.593***	0.083***	0.202***	80	0.578	0.932***	-0.397***	-0.557***	80	0.882
	(0.082)	(0.021)	(0.058)			(0.040)	(0.136)	(0.121)		
Luxembourg	0.262*	0.009	0.425***	69	0.348	0.896***	0.673***	-0.367***	69	0.917
	(0.139)	(0.027)	(0.070)			(0.035)	(0.151)	(0.072)		
Malta	0.863***	0.160***	0.272***	77	0.511	0.690***	-1.241***	-0.498***	77	0.891
	(0.183)	(0.043)	(0.075)			(0.063)	(0.207)	(0.137)		
Netherlands	0.642***	0.038*	0.416***	80	0.588	0.639***	-0.975***	-1.019***	80	0.831
	(0.078)	(0.020)	(0.099)			(0.073)	(0.129)	(0.265)		
Portugal	0.554***	0.030***	0.146*	80	0.518	0.982***	-1.278***	-0.852***	80	0.974
	(0.099)	(0.006)	(0.075)			(0.015)	(0.268)	(0.199)		
Slovakia	0.458***	0.086***	0.214***	80	0.487	0.879***	-0.358*	-0.663***	80	0.788
	(0.067)	(0.021)	(0.054)			(0.044)	(0.184)	(0.185)		
Slovenia	0.387***	0.027***	0.345***	81	0.318	0.977***	-0.685***	-1.042***	81	0.953
	(0.101)	(0.010)	(0.058)			(0.021)	(0.174)	(0.157)		
Spain	0.829***	0.022*	0.200**	81	0.673	0.956***	-1.137***	-0.818***	81	0.971
	(0.061)	(0.013)	(0.076)			(0.026)	(0.129)	(0.188)		

Notes: (a) OLS Estimates; (b) Robust standard errors in brackets; (c) Constant term estimated, but omitted for reasons of parsimony; (d) *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

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