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Working Paper

Fiscal Sustainability, Fiscal Reactions, Pitfalls and Determinants

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Abstract

We examine the sustainability of public finances and its determinants for 19 Eurozone countries from 1995 to 2020. We conclude for the existence of panel cointegration between government revenues and expenditures; primary government balance and one-period lagged public debt-to-GDP ratio; and public debt-to-GDP ratio and one-period lagged primary government balance. The estimated fiscal reaction functions suggest the existence of a Ricardian fiscal regime. Finally, modelling via time-varying coefficients, we find that fiscal sustainability increases with growth, fiscal balances and fiscal rules indices, and decreases with trade openness, current account balances, government effectiveness index, after 2010, and with sovereign ratings assigned by the main rating agencies.

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

Keywords: fiscal sustainability, budget balance, public debt, panel data, time-varying coefficients, Eurozone, sovereign ratings.

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1. Introduction

The growth of public debt seen in several developed countries in recent decades, and, in particular, following the crisis of the great confinement associated with the COVID-19 pandemic, is currently a matter of concern on the part of economic policy makers. Therefore, the sustainability of public accounts is assumed an important issue within the scope of public policies, but is nevertheless plagued with pitfalls such as measurement and estimation difficulties.

In the context of Economic and Monetary Union (EMU), and with the aim of ensuring fiscal sustainability, the treaties require that the share of public debt be less than 60% of GDP and the fiscal balance not less than -3% of GDP. However, most EMU countries exhibit public debt-to-GDP ratios above 60% of GDP, and some countries have ratios above 100%, such as Greece, Italy, Portugal, Spain, France, Belgium, and Cyprus. The European Central Bank (ECB) assumes budgetary discipline as crucial for the implementation of monetary policy, and thus guaranteeing the primary objective of price stability.

The literature advances the existence of two fiscal regimes: Ricardian and non-Ricardian. In a Ricardian regime, future tax revenues are expected to be used to support the government's future liabilities. In order to ensure the sustainability of public finances, it is assumed that the primary government balance reacts to the past public debt-to-GDP ratio. On the other hand, in a non-Ricardian regime, since part of the new public debt is financed using monetary issuance, the fiscal authorities do not commit themselves in the future to match completely new public debt with future taxes. In this fiscal regime, the government determines the primary balance independently of the stock of public debt. The existence of a Ricardian fiscal regime is a necessary, though not sufficient, condition for fiscal sustainability.

Fiscal sustainability has been the subject of significant empirical work over the past three decades. In this context, the studies by Hamilton and Flavin (1986) and Trahan and Walsh (1988) applied to the United States are pioneers. Next, Vanhorebeek and Rompuy (1995), Papadopoulos and Sidiropoulos (1999) and Afonso (2005) investigate fiscal solvency for several European Union countries. More recently, Afonso and Jalles (2018) estimate fiscal reaction functions considering a panel of 173 countries and depending on the time and groups of countries, the results are different. For advanced and Eurozone countries, a Ricardian fiscal regime is verified.

The purpose of this paper is to investigate the fiscal solvency for the 19 Eurozone countries in the period between 1995 and 2020. To this end, we use several empirical

methodologies, commonly performed in this literature, namely: (i) the Pesaran (2007) panel unit root test, who consider the presence of cross-sectional dependence; (ii) Pedroni (2004) panel cointegration tests; and (iii) the Granger non-causality test proposed by Dumitrescu and Hurlin (2012). Furthermore, we estimate fiscal reaction functions, using the Pesaran (2006) Common Correlated Effects Mean Group (CCEMG) Estimator, with the aim of ascertaining the response of the primary government balance to the past public debt-to-GDP ratio and the response of the public debt-to-GDP ratio to the past primary government balance. Finally, we construct the time-varying responses of the primary government balance to unit changes in the public debt-to-GDP ratio lagged for one period, based on Schlicht (2003) methodology, and then identify factors that explain these marginal responses. One of the factors that we accept as relevant are the ratings assigned by the financial rating agencies, namely Moody's, Standard and Poor's and Fitch. This is the novelty of this work, given that, to the best of our knowledge, this is the first research applied to Eurozone countries that assumes that the response of the primary government balance to changes in the past public debt-to-GDP ratio may vary over time and lists explanatory factors for the marginal responses.

The remainder of the paper is organised as follows. Section 2 presents a literature review, both theoretical and empirical, on fiscal sustainability. Section 3 explains the methodological framework. Section 4 describes the data and reports the empirical results obtained. Section 5 concludes.

2. Literature

2.1. Theoretical Issues

There is a problem of fiscal sustainability when "it has become clear that the claims of the bond-holders are more than the tax payers can support" (Keynes, 1923, pp. 55), *A Tract on Monetary Reform*, p. 55. Indeed, and according notably to Hamilton and Flavin (1986) and based on the present value budget constraint (PVBC), there are two definitions of fiscal sustainability, namely: (i) the value of current public debt equals the sum of future primary government surpluses; and (ii) the present value of public debt tends to zero in infinity.

To test the presence of non-Ponzi games (and thus the sustainability of public finances), we can verify the stationarity of the series in first differences of the stock of real public debt, ΔB_t, and the cointegration relationship between the primary government balance, s_t, and the lagged stock of the public debt, B_{t-1}:

$$s_t = \alpha + \beta B_{t-1} + \varphi_t. \quad (1)$$

Trahan and Walsh (1991) note that the stationary of the first differences of the stock of real public debt is a sufficient condition for fiscal sustainability. Albeit the rejection of stationarity does not necessarily mean the absence of sustainability in the public finances (Bohn, 2007). In addition, Bohn (1998) showed that β >0 is sufficient to ensure solvency and fiscal sustainability. Blanchard *et al.* (2020) also argue about the importance of the estimated β coefficient in (1).[1]

The sustainability of public finances can also be assessed by studying the cointegration relationship between government revenue, R_t, and expenditure, G_t.[2] Under the non-Ponzi game condition, R_t and G_t must be cointegrated variables of order one for their first differences to be stationary. The procedure involves testing the following cointegration equation:

$$R_t = \gamma + \theta G_t + \omega_t. \quad (2)$$

in addition, if the null hypothesis of the existence of non-cointegration is rejected, ω_t must be stationary.

Hakkio and Rush (1991) sustain that when the government revenues and expenditures series are non-stationary, the existence of cointegration between both variables is a necessary condition for the government to comply with the present value budget constraint.

Additionally, Sargent and Wallace (1981) define a Ricardian regime as a monetary predominance regime, in which the demand and supply of money determine the price level. A non-Ricardian regime, on the other hand, is a regime of fiscal predominance, in which prices would be endogenously determined by the government budget constraint. In a Ricardian regime, the monetary authorities are active, and the government has to attain primary government surpluses in order that its budget constraint is consistent with the repayment of the initial stock of real public debt, its behavior being passive. In a non-Ricardian regime, the government chooses an active fiscal policy and, consequently, the primary budgets are not adjusted endogenously in order to ensure compliance with the government budget constraint that satisfies the price level implicit in the money demand.

The Fiscal Theory of the Price Level (FTPL), proposed by Leeper (1991), Sims (1994) and Woodford (1994, 1995), advances that fiscal policy can play an important role in determining the price level, as monetary policy. The fiscal regime in which FTPL operates is non-Ricardian, in which the government may autonomously decide on the fiscal balance and public debt, influencing the determination of the price level. In this scenario, the monetary

[1] See also Debrun *et al.* (2019) for a review on debt sustainability.
[2] The implicit assumption is the stationarity of the real interest rate.

authority endogenously set the money supply and taking the price level from the government budget constraint. Primary government balances could be determined by the government without taking account of the level of public debt. Money and prices would need to adjust to the level of government debt to ensure the fulfillment of the government intertemporal budget constraint.

There are two perspectives to empirically test the FTPL, namely: (i) the backward-looking approach (see Bohn, 1998), which considers that, in a Ricardian regime, the increase in public debt in the past would result in a higher primary government surpluses in the present; and (ii) the forward-looking approach (see Canzoneri *et al.*, 2001), which consists in the fact that, in a Ricardian regime, a budget surplus results in the reduction of public debt in the future.

2.2. Empirical Studies

The topic of sustainability of public accounts is extensively studied in the empirical literature. For instance, Bravo and Silvestre (2002) test the existence of cointegration between government revenues and expenditures for 11 European Union countries between 1960 and 2000. The results allow us to conclude that public finances are sustainable in the cases of Austria, France, Germany, the Netherlands, and the United Kingdom.

Afonso (2008), using a sample of 15 European Union countries between 1970 and 2003, concludes by the occurrence of Ricardian fiscal regimes. This conclusion holds even considering the effects of the entry into force of the Maastricht Treaty (in 1992) and the Stability and Growth Pact (in 1996). Furthermore, in election years, the verification of a Ricardian fiscal regime appears weakened.

Afonso and Rault (2010) find that fiscal policy was sustainable between 1970 and 2006 for a panel of 15 European Union countries. The fiscal solvency condition is fulfilled in the following countries: Austria, Finland, France, Germany, the Netherlands, the United Kingdom, and Sweden.

Considering a sample of 11 Eurozone countries and using quarterly data between 1999 and 2013, Afonso and Jalles (2017) suggest the occurrence of a Ricardian regime in Belgium, France, Germany, and the Netherlands, and the non-verification of the Fiscal Theory of the Price Level. In addition, the authors compute the time-varying responses of the primary government balance to changes in the lagged public debt-to-GDP ratio. The global financial crisis had a negative impact and expenditure-based fiscal rules are important determinants of fiscal sustainability.

Brady and Magazzino (2018), in turn, study the sustainability of public accounts for 28 European Union countries in the period 1980-2015. The authors find evidence that suggests a panel cointegration relationship between government revenues and expenditures as well as between the primary government balance and the public debt-to-GDP ratio. For Portugal, Ireland, Italy, Greece, and Spain, the results obtained indicate a lack of fiscal sustainability.

Taking a panel made up of 17 Eurozone countries between 1970 and 2011, Weinchenrieder and Zimmer (2014) estimate fiscal reaction functions. In the period between the signing of the Maastricht Treaty and the introduction of the single currency, membership of the Eurozone reduced the average response of the primary budget balance to the lagged public debt-to-GDP ratio. Compared to the period prior to the Maastricht Treaty, membership of the Eurozone resulted in a higher response.

Lee *et al.* (2018), using the panel dataset of 26 European Union countries for the period between 1950 and 2014, assess fiscal sustainability for five regional groups of countries. For Benelux, Northern and Western European countries, the fiscal solvency condition is satisfied, but not for Eastern and Southern European countries. For Eurozone countries, fiscal sustainability is weaker relative to non-Eurozone countries. The solvency tests that allow time-varying marginal responses show that for Southern European countries the fiscal solvency conditions are not satisfied.

3. Methodology

In order to study fiscal sustainability in Eurozone countries from 1995 to 2020, we use several empirical methodologies in a panel set up. Our rational for a panel approach stems from the fact that: (i) we can use the information contained in the cross-section dimension and increase the performance and accuracy of the tests; (ii) cross-country dependence can mirror common changes in the behavior of fiscal authorities (run-up to the EMU, Stability and Growth Pact, peer pressure, capital markets views, sovereign rating grouping, increased business cycle synchronization); and (iii) common policy shocks can affect fiscal positions in several and/or all EMU countries. In fact, cross-section dependence can occur due to factors such as observed common factors, spatial spillover effects, unobserved common factors or general residual interdependence. In this regard, the Pesaran (2004) cross-sectional dependence test allow us to assess the correlation coefficients between the time series for each panel member. The null hypothesis is the cross-sectional independence. This test is robust to non-stationarity, parameter heterogeneity and structural breaks and it performs well even in small samples.

The second-generation panel unit root of Pesaran (2007) is applied to heterogeneous panels with cross-sectional dependence and it is based on the mean of individual Dickey-Fuller (or Augmented Dickey-Fuller) statistics of each unit in the panel. The null hypothesis assumes that all series are non-stationary. To eliminate the cross-sectional dependence, the standard regressions are augmented with the cross-sectional averages of lagged levels and first-differences of the individual series (cointegrated augmented Dickey-Fuller statistics).

The panel cointegration tests of Pedroni (2004) are a set of seven residual-based tests that assumes the null hypothesis of non-cointegration in heterogenous panels with one or more non-stationary regressors. The estimated tests admit heterogeneity in cointegration vectors and the dynamics of the underlying errors process across the cross-sectional units are estimated as residual tests. Nevertheless, these tests do not consider structural breaks in the cointegration relationship and cross-sectional dependence. There are two classes of statistics. The first (with four statistics) is based on pooling the residuals of the regression along the within-dimension of the panel. The second (with the latter three statistics) is based on pooling the are residuals of the regression along the between-dimension of the panel permitting distinct slopes values.

The Dumitrescu and Hurlin (2002) test is a Granger (1969) non-causality test for heterogenous panel data sets and takes into account both the heterogeneity of the causal relationships and the heterogeneity of the regression model used to test for Granger causality. The null hypothesis corresponds to the absence of causality for all cross units of the panel. The test statistic is based on the individual Wald statistics of Granger non-causality averaged across the cross-section units. This test can be applied to balanced and heterogenous panels, with or without cross-sectional dependence and it is designed to detect causality at the panel level. The rejection of the null hypothesis does not exclude non-causality for some units of the panel.

The Pesaran (2006) Common Correlated Effects Mean Group (CCEMG) Estimator 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 mean group estimator is based on the separate estimation of the coefficients for each cross-section unit, through the ordinary least squares, and then computing the arithmetic mean of these coefficients. Therefore, the 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 accommodating the possibility that the coefficients are not the same for all cross-section units, that is, it admits heterogeneous responses in each one of them.

Finally, we estimate the marginal responses of the primary government balance to unit changes in the lagged share of public debt, using the methodology proposed by Schlicht (2003), by introducing the assumption that the regression coefficients may vary over time. Previously, we start with the following fiscal reaction function estimated for each country *i* of our sample, like Bohn (1998):

$$PGB_{it} = \alpha_0 + \alpha_1 d_{it-1} + \mu_{it}. \quad (3)$$

where PGB_{it} is the primary government balance-to-GDP ratio in country *i* in year *t*; d_{it-1} corresponds to the stock of the public debt-to-GDP ratio lagged by one period in country *i* in year *t-1*; and μ_{it} is the random disturbance term of country *i* in year *t*.

The Varying-Coefficient model assumes that α_1 change slowly and not systematically over time:

$$\alpha_{1i,t} = \alpha_{1i,t-1} + \tau_{it}. \quad (4)$$

As it is assumed that the coefficients are random walks, the expected value of the coefficient at time *t* is equal to the value of the coefficient in time *t-1*. The change of the coefficients is denoted by τ_{it}, which is assumed to be normally distributed with zero mean and variance σ_i^2. The variances σ_i^2 are computed using a method of moments estimator, which coincides with the maximum-likelihood estimator for large samples, although it is statistically more efficient and numerically more transparent and straightforward to interpret in small samples. The expression (3) is a special case when the variance of the disturbances in the coefficients approaches to zero.

Schlicht (2003)´s method has several advantages compared to other method to compute TVC (time-varying coefficients), such as rolling windows and Gaussian methods. First, it allows using all observations in the sample to estimate the magnitude of spillover in each year, which by construction is not possible in the rolling windows approach. Second, changes in the size of estimated TVC in a given year come from innovations in the same year, rather than from shocks occurring in neighbouring years. Third, it reflects the fact that changes in policy are slow and depend on the immediate past. Lastly, it reduces reverse causality problems when the estimated TVC is used as explanatory variable since it depends on the past.

Next, we use the computed time-varying estimates as dependent variables and identify explanatory factors for these marginal responses. The equations that identify the explanatory factors of the TVC are estimated using POLS (Pooled Ordinary Least Squares) with 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. We chose this model and not a fixed effects model, since for most countries the time-varying coefficients are almost or even constant. In this case, we admit that a fixed effects model would not be adequate.

4. Empirical Assessment

4.1. 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, from 1995 to 2020.

We consider the series of government revenues (REV), government expenditures (EXP), primary government balance (PGB), public debt-to-GDP ratio (d), and output gap (OUTGAP), as a percentage of GDP. The stock of real public debt (PD) results from the stock of nominal public debt adjusted by the GDP deflator.

Moreover, we estimate the time-varying coefficients of the response of the primary government balance to a unit change in the public debt-to-GDP ratio lagged by one period (d_TVC), both variables as a percentage of GDP. As explanatory variables of these marginal responses, we choose: real GDP growth rate (GR), inflation rate (INF), trade openness (TO), long-term real interest rate (R), current account balance as a percentage of GDP (CA), general government balance as a percentage of GDP (GB), government effectiveness index (GOV), fiscal rules index (FR), dummy variable that takes the value 1 from 2010 (D2010), and ratings assigned by Moody's, Standard and Poor's and Fitch on the 17 and 21 level scale (RATING-M-A, RATING-M-B, RATING-SP-A, RATING-SP-B, RATING-F-A, RATING-F-B, respectively).

We provide a detailed description of the variables as well as of the data sources in Table A1, in the Appendix. Table A2 presents the quantitative sovereign rating scale that we assigned to Moody's, Standard and Poor's and Fitch ratings, using a 17 and 21 notches scale. Tables A3 and A4 show the descriptive statistics and the correlations matrix between variables considered in time-varying analysis, respectively. In Table A5, we report the correlation coefficients between the fiscal sustainability time-varying coefficients and the lagged public debt-to-GDP ratio, and the ratings assigned by rating agencies.

In addition, Figures A1-A7, also in the Appendix, show for some countries the relationship between fiscal sustainability time-varying coefficients and lagged public debt-to-

GDP ratio.[3] As can be seen, and as one might expect, for Cyprus, France, Greece, Italy, Portugal and Slovenia there is a negative relationship between the fiscal sustainability time-varying coefficients and the lagged public debt-to-GDP ratio. For Slovakia, however, the relationship is positive.

4.2. Results

We performed Pesaran (2004) cross-sectional dependence test for the series of government revenues and expenditures, primary government balance and public debt ratio, as a percentage of GDP, and the first differences of the stock of real public debt.[4] The conclusion suggests the existence of cross-sectional dependence of the series. The presence of cross-section dependence is expected given the existence of a single monetary policy among the Eurozone countries, the integration of financial markets and the feedback and spillover effects between the economies. In this case, the results of the first-generation panel unit root tests unfeasible. Thus, we implemented the second-generation panel unit root test by Pesaran (2007), which considers the existence of cross-sectional dependence of the variables.

Tables 1 and 2 show the results of the Pesaran (2007) panel unit root tests with constant term and constant term and linear time trend, respectively, for the series of government revenues and expenditures, primary government balance and public debt ratio, as a percentage of GDP, and the first differences of the stock of real public debt. The series of government revenues and expenditures and of the first differences of the stock of real public debt are stationary in panel, which points to the existence of sustainability of public finances in the Eurozone countries between 1995 and 2020. Instead, primary government balance and public debt-to-GDP ratio are not stationary at levels.

The results of Pedroni (2004) panel cointegration tests are presented in Table 3, considering the following pairs: (i) government revenues and expenditures; (ii) primary government balance and public debt-to-GDP ratio lagged by one period; and (iii) public debt-to-GDP ratio and primary government balance lagged by one period, with and without trend. We perform four within-group tests and three between-group tests.[5] From the analysis of Table

[3] We only present the charts of the relationship between the fiscal sustainability time-varying coefficients and the lagged public debt-to-GDP ratio for Cyprus, France, Greece, Italy, Portugal, Slovakia and Slovenia, since for the remaining countries the time-varying coefficients practically do not change or do not change, that is, they are almost or even constant over time.

[4] These results are available upon request.

[5] The rows labelled within-dimension contain the computed value of the statistics based on estimators that pool the auto-regressive coefficient across different countries for the unit root tests on the estimated residuals. The rows labelled between-dimension report the computed value of the statistics based on estimators that average individually calculated coefficients for each country.

3, it is generally concluded that there is panel cointegration between the pairs of the series considered, and, therefore, long-term stable relationships between the series under study.

Table 1: Pesaran (2007) Panel Unit Toot Tests, including constant term

Variable	CIPS	CIPS*	p-value
Revenues (% GDP)	-2.611	-3.871	0.000
Expenditures (% GDP)	-2.169	-1.881	0.030
Primary balance (% GDP)	-1.838	-0.395	0.346
Stock of public debt (% GDP)	-1.987	-1.063	0.144
First differences of the stock of real public debt	-2.800	-4.719	0.000

Notes: (a) The null hypothesis is non-stationary; (b) We assume one lag; (c) CIPS* is the truncated cross-section augmented Im-Pesaran-Shin test statistic.

Table 2: Pesaran (2007) Panel Unit Toot Tests, including constant term and linear time trend

Variable	CIPS	CIPS*	p-value
Revenues (% GDP)	-2.758	-2.100	0.018
Expenditures (% GDP)	-2.823	-2.403	0.008
Primary balance (% GDP)	-2.540	-1.080	0.140
Stock of public debt (% GDP)	-2.292	0.086	0.534
First differences of the stock of real public debt	-3.194	-4.143	0.000

Notes: (a) The null hypothesis is non-stationary; (b) We assume one lag; (c) CIPS* is the truncated cross-section augmented Im-Pesaran-Shin test statistic.

Table 3: Pedroni (2004) Panel Cointegration Tests

	Relation	**Revenues and expenditures**		**Primary balance and lagged debt**		**Debt and lagged primary balance**	
		No trend	Trend	No trend	Trend	No trend	Trend
Within-dimension	Panel *v*	2.319	0.837	2.3	0.041	-0.977	-0.343
	Panel *p*	-3.42	-2.872	-3.701	-2.658	1.727	1.975
	Panel ADF	-1.554	-2.194	-4.608	-4.863	1.935	0.191
	Panel PP	-3.318	-4.828	-4.169	-4.5	1.517	1.092
Between-dimension	Group *p*	-2.064	-0.88	-1.882	-0.539	2.932	3.08
	Group ADF	-0.497	-1.8	-4.651	-3.243	2.859	0.759
	Group PP	-3.206	-4.336	-3.616	-3.341	2.627	2.08

Notes: (a) The series are assessed as a percentage of GDP; (b) The null hypothesis is non-cointegration; (c) Under the null hypothesis all the statistics follow a standard normal distribution.

Table 4 reports the results of Dumitrescu and Hurlin (2012) tests for four accepted null hypotheses, using the algorithm developed by Lopez and Weber (2017). At high levels of significance, we can advance the existence of Granger panel non-causality in the following directions: public expenditures cause public revenues; one-period lagged public debt-to-GDP ratio causes primary government balance; and one-period lagged primary government balance causes public debt-to-GDP ratio. In the first case, the government adjusts revenues to the level of planned expenditures (Barro, 1979). In the second case, the increase in the public debt-to-GDP ratio in the past results in a higher primary government balance in the present (Bohn, 1998). In the third case, a positive primary government balance in the present translates into a reduction in the public debt-to-GDP ratio in the future (Canzoneri *et al.*, 2001). Furthermore, no statistical significance was found in the direction of public revenues causing public expenditures. In this case, Friedman's (1978) perspective that the authorities adjust expenditures to the level of revenues, allowing to control the increase in the size of the public sector, is not supported.

Table 4: Dumitrescu and Hurlin (2012) Tests, 1996-2020

Null Hypothesis	Z bar	p-value	Z bar tilde	p-value
H0: EXP does not Granger-cause REV	5.202	0.000	4.068	0.000
H0: REV does not Granger-cause EXP	0.438	0.662	0.095	0.925
H0: Lagged debt does not Granger-cause PGB	3.48	0.001	2.633	0.009
H0: Lagged PGB does not Granger-cause debt	2.994	0.003	2.227	0.026

Notes: (a) The null hypothesis is Granger non-causality; (b) The tests were performed with one lag; (c) Under the null hypothesis, the statistics follow a standard normal distribution.

Table 5 reports the results of the estimates obtained using the Pesaran (2006) Common Correlated Effects Mean Group (CCEMG) Estimator. The primary government balance and the public debt ratio, both as a percentage of GDP, are explained by their lagged values of one period and also based on the public debt-to-GDP ratio and the primary budget balance, respectively, in specifications (1) and (3). In specifications (2) and (4), the output gap is added as an explanatory variable, in order to control the cyclical fluctuations of the output. The variables under study are persistent, since their one-period lagged term is positive and highly significant. The higher the public debt-to-GDP ratio, the higher the primary government balance, and, in turn, the higher the primary government balance, the lower the public debt-to-GDP ratio. These results are highly significant and confirm both the perspectives of Bohn (1998) and Canzoneri *et al.* (2001), respectively. With the introduction of the output gap as a

regressor, the initial results are maintained, and, as expected, this variable improves the primary government balance and reduces the public debt-to-GDP ratio. These results mean that fiscal policy in the Eurozone is pro-cyclical and periods of economic expansion improve the balance of public accounts and contribute to the reduction of the public debt ratio, helping to ensure fiscal sustainability. In addition, the obtained results corroborate the conclusions drawn based on Tables 3 and 4.

Table 5: Pesaran (2006) CCEMG Estimator Results

	Dependent Variable: Primary Balance as a percentage of GDP (PGB)		Dependent Variable: Public Debt as a percentage of GDP (d)	
Regressors/ Specification	(1)	(2)	(3)	(4)
PGB_{it-1}	0.327***	0.192***	-0.527***	-0.43***
	(0.064)	(0.073)	(0.16)	(0.067)
d_{it-1}	0.093***	0.105***	0.754***	0.697***
	(0.023)	(0.028)	(0.035)	(0.067)
$OUTGAP_{it}$		0.343***		-0.53***
		(0.064)		(0.135)
Cross-section averaged regressors for:				
PGB_{it}	0.907***	0.78***		
	(0.058)	(0.129)		
d_{it}			0.988***	0.905***
			(0.097)	(0.107)
PGB_{it-1}	-0.401***	-0.302**	0.637***	0.53*
	(0.095)	(0.123)	(0.159)	(0.272)
d_{it-1}	-0.065***	-0.062**	-0.754***	-0.673***
	(0.024)	(0.029)	(0.082)	(0.116)
$OUTGAP_{it}$		-0.204**		0.419
		(0.094)		(0.272)
Obs.	475	473	475	473
Wald	42.10	49.65	483.39	133.63
p-value	0.0000	0.0000	0.0000	0.0000
RMSE	0.0157	0.0137	0.0279	0.0230

Notes: (a) All coefficients represent averages across groups (countries); (b) Coefficient averages computed as outlier-robust means, using robust regression; (c) 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.

Table 6 presents the estimates of the explanatory factors of the time-varying coefficients of the response of the primary government balance to a unit change in the public debt-to-GDP ratio lagged by one period, with both variables as a percentage of GDP. The growth rate of real

GDP per capita, the long-term real interest rate, the fiscal balance and the fiscal rules index increase the primary government balance responses. On the contrary, trade openness, the current account balance and the government effectiveness index diminish the responses. Finally, the inflation rate has a positive sign, and the dummy variable that takes the value 1 from 2010 onwards has a negative sign, although these signs are non-significant.

Table 6: I Time-varying fiscal sustainability Estimates, 1996-2020

Regressors/Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GR_{it}	0.458**	0.477*	0.297*	0.293*	0.280*	0.469**	0.463***
	(0.183)	(0.229)	(0.156)	(0.161)	(0.152)	(0.169)	(0.153)
INF_{it}	0.840***	1.153***	0.215	0.214	0.098	0.465*	0.410
	(0.166)	(0.341)	(0.232)	(0.234)	(0.212)	(0.246)	(0.241)
TO_{it}	-0.042***	-0.046***	-0.031***	-0.031***	-0.030***	-0.030***	-0.028***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.006)	(0.006)
R_{it}		0.514***	0.461**	0.464**	0.425*	0.776**	0.756**
		(0.172)	(0.185)	(0.220)	(0.222)	(0.273)	(0.279)
CA_{it}			-0.898***	-0.901***	-0.630***	-0.740***	-0.732***
			(0.150)	(0.155)	(0.178)	(0.218)	(0.220)
GB_{it}				0.010	0.284*	0.290**	0.247**
				(0.197)	(0.150)	(0.104)	(0.104)
GOV_{it}					-0.068***	-0.056***	-0.058***
					(0.014)	(0.016)	(0.017)
FR_{it}						0.016**	0.018**
						(0.007)	(0.007)
$D2010_{it}$							-0.011
							(0.008)
Observations	475	439	439	439	394	375	375
R-squared	0.109	0.152	0.312	0.312	0.356	0.389	0.390
Number of groups	19	19	19	19	19	19	19

Notes: (a) POLS (Pooled Ordinary Least Squares) with Driscoll-Kraay errors Estimates; (b) The dependent variable is the response of the primary government balance to a unit change in public debt lagged by a period, 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.

Based on specification (7) in Table 6, we introduce as explanatory variables the ratings assigned by three rating agencies, namely, Moody's, Standard and Poor's and Fitch, on the scales at 17 (A) and 21 (B) notches. Table 7 shows the results of the estimations. The higher the ratings assigned by Moody's and Standard and Poor's, the lower the response of the primary government balance to changes in the lagged public debt-to-GDP ratio, at 1% and 5% levels of significance, respectively, for both rating scales. This result suggests that the higher the rating, the less urgent the need to adopt Ricardian fiscal behavior. Thus, countries with lower ratings,

which reflect higher sovereign credit risk, and generally a higher public debt-to-GDP ratio, face additional pressure to obtain primary fiscal surpluses. In turn, the ratings assigned by Fitch, although with a negative sign, are insignificant.

Table 7: II Time-varying fiscal sustainability Estimates, 1996-2020

Regressors/Specification	(8)	(9)	(10)	(11)	(12)	(13)
GR_{it}	0.434**	0.448**	0.414**	0.414**	0.371**	0.374**
	(0.162)	(0.163)	(0.152)	(0.152)	(0.149)	(0.150)
INF_{it}	0.247	0.242	0.366	0.366	0.215	0.216
	(0.157)	(0.153)	(0.252)	(0.252)	(0.151)	(0.150)
TO_{it}	-0.031***	-0.030***	-0.029***	-0.029***	-0.029***	-0.029***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
R_{it}	0.466	0.483	0.540	0.540	0.513	0.519
	(0.306)	(0.314)	(0.363)	(0.363)	(0.332)	(0.333)
CA_{it}	-0.671***	-0.677***	-0.663**	-0.663**	-0.711***	-0.712***
	(0.227)	(0.228)	(0.237)	(0.237)	(0.239)	(0.239)
GB_{it}	0.314***	0.307***	0.239**	0.239**	0.255**	0.253**
	(0.102)	(0.102)	(0.111)	(0.111)	(0.113)	(0.113)
GOV_{it}	-0.041**	-0.044***	-0.037**	-0.037**	-0.045**	-0.046**
	(0.015)	(0.015)	(0.017)	(0.017)	(0.018)	(0.017)
FR_{it}	0.012*	0.012*	0.015*	0.015*	0.015*	0.015*
	(0.006)	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)
$D2010_{it}$	-0.026**	-0.025**	-0.022**	-0.022**	-0.016*	-0.016
	(0.009)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)
RATING-M-A_{it}	-0.005***					
	(0.001)					
RATING-M-B_{it}		-0.004***				
		(0.001)				
RATING-SP-A_{it}			-0.005**			
			(0.002)			
RATING-SP-B_{it}				-0.005**		
				(0.002)		
RATING-F-A_{it}					-0.003	
					(0.002)	
RATING-F-B_{it}						-0.003
						(0.002)
Observations	362	362	374	374	370	370
R-squared	0.405	0.402	0.396	0.396	0.382	0.382
Number of groups	19	19	19	19	19	19

Notes: (a) POLS (Pooled Ordinary Least Squares) with Driscoll-Kraay errors Estimates; (b) The dependent variable is the response of the primary government balance to a unit change in public debt lagged by a period, 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.

As reported by Table 6, the growth rate of real GDP per capita, the fiscal balance and the fiscal rules index have positive impacts, and trade openness, the current account balance and government effectiveness have negative effects. From 2010 onwards, there is a reduction in the response of the primary government balance to changes in the public debt-to-GDP ratio lagged by one period. When rating variables are added, the real long-term interest rate, although remaining positive, loses statistical significance. This result is not surprising, as there is an inverse relationship between the interest rates on sovereign bonds and the credit ratings of the rating agencies assigned to the States.

5. Conclusion

We have studied fiscal sustainability for Eurozone countries for the period 1995-2020, through several panel data techniques. The Pesaran test (2007) allows for the conclusion of the fiscal solvency of the Eurozone as a whole since the government revenues and expenditures series and the first differences of the stock of real public debt are stationary in panel. The Pedroni (2004) panel cointegration tests point to the existence of long-term stable relationships between: (i) government revenues and expenditures; (ii) primary government balance and public debt-to-GDP ratio lagged by one period; and (iii) public debt-to-GDP ratio and primary government balance lagged by one period. The Dumitrescu and Hurlin (2012) approach suggests the existence of Granger non-causality in panel for the three pairs identified. However, no evidence was found to support the existence of Granger non-causality in the panel running from revenues to expenditures.

The results of the estimations of fiscal reaction functions indicate a Ricardian fiscal regime (or monetary predominance regime) in the Eurozone and confirm the perspectives of Bohn (1998) and Canzoneri *et al.* (2001), contradicting the Fiscal Theory of the Price Level. More specifically, fiscal authorities increase the primary government balance in response to higher government debt ratios and primary government balances are used to reduce government debt ratios. Furthermore, fiscal policy in the Eurozone is pro-cyclical and economic growth is a crucial element in ensuring the sustainability of public finances.

Among the factors that explain the time-varying coefficients of the responses of the primary government balance to unit changes in the public debt-to-GDP ratio, we conclude that economic growth, the government budget balance as a percentage of GDP and fiscal rules index have a positive effect, and trade openness, the current account balance as a percentage of GDP and the government effectiveness index have a negative influence. Moreover, from 2010

onwards and the higher the sovereign credit notations assigned by Moody's and Standard and Poor's, the lower the marginal response of the fiscal reaction coefficients.

In the current context of debate at the Eurozone level about fiscal rules, the results obtained confirm their importance in contributing to the sustainability of public finances. Nonetheless, there are other factors that are equally or even more relevant, which, from the point of view of the economic policy maker, should be considered, namely and again, economic growth.

One of the limitations of this analysis is the fact that we did not assess fiscal sustainability for each country taken individually. This issue is relevant, as countries may exhibit different fiscal solvency profiles and fiscal regimes, especially those with high public debt-to-GDP ratios. Accordingly, a future research topic could be the assessment of the sustainability of public finances for Eurozone countries, using recent quarterly data, which would allow a greater number of observations per country, and thus resorting to time-series analysis and estimate country-by-country fiscal reaction functions. This approach would perhaps make it possible to highlight different dynamics of fiscal sustainability among Eurozone countries, that is, it would open the black box, both in terms of the relationship between government revenues and expenditures as well as the responses of the primary government balance to changes in the public debt-to-GDP ratio and vice versa.

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Appendix

Table A1: Variables, definitions, and data sources

Variable	Definition	Source
REV	government total revenues as a percentage of GDP	AMECO
EXP	government total expenditures as a percentage of GDP	AMECO
PGB	primary government balance as a percentage of GDP	AMECO
d	ratio of the public debt as a percentage of GDP	AMECO
OUTGAP	gap between effective and potential gross domestic product at constant market prices	AMECO
PD	stock of real public debt, the stock of nominal public debt adjusted by the GDP deflator	Author´s calculations based on AMECO data
d_TVC	marginal response of the primary government balance to a unit change in the share of public debt, both variables as a percentage of GDP	Author´s calculations based on Schlicht (2003)' procedure
GR	real GDP growth rate per capita compared to the previous year, PPP (constant 2017 international $) real GDP per capita	Author´s calculations based on World Bank data
INF	inflation rate	World Bank
TO	trade openness, the sum of exports with imports measured as a share of GDP	Author´s calculations based on AMECO data
R	long-term real interest rate	AMECO
CA	current account balance as a percentage of GDP	AMECO
GB	general government balance as a percentage of GDP	AMECO
GOV	Government Effectiveness Index	Worldwide Governance Indicators (2021)
FR	Fiscal Rules Index	European Commission (2021)
D2010	Dummy that takes the value 1 from 2010, inclusive, and 0, otherwise	Own definition
RATING-M-A	rating assigned by Moody's on the 17-level scale	Rating agency, and own calculations
RATING-M-B	rating assigned by Moody's on the 21-level scale	Rating agency, and own calculations
RATING-SP-A	rating assigned by Standard and Poor´s on the 17-level scale	Rating agency, and own calculations
RATING-SP-B	rating assigned by Standard and Poor´s on the 21-level scale	Rating agency, and own calculations
RATING-F-A	rating assigned by Fitch on the 17-level scale	Rating agency, and own calculations
RATING-F-B	rating assigned by Fitch on the 21-level scale	Rating agency, and own calculations

Table A2: Qualitative sovereign rating scale

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

Source: Rating agencies, and own calculations.

Table A3: Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Maximum	Minimum
d_TVC	475	0.083	0.129	0.431	-0.240
GR	475	0.021	0.041	0.240	-0.145
INF	475	0.024	0.027	0.246	-0.045
TO	475	1.224	0.689	3.801	0.375
R	439	0.018	0.033	0.244	-0.123
GB	475	-0.027	0.037	0.069	-0.321
CA	475	-0.010	0.059	0.118	-0.280
GOV	418	1.238	0.491	2.261	0.145
FR	456	0.209	1.006	3.069	-0.986
RATING-M-A	441	13.435	3.789	17	1
RATING-M-B	441	17.399	3.919	21	1
RATING-SP-A	471	13.677	3.434	17	1
RATING-SP-B	471	17.677	3.434	21	5
RATING-F-A	458	13.803	3.388	17	1
RATING-F-B	458	17.795	3.422	21	4

Table A4: Correlation matrix

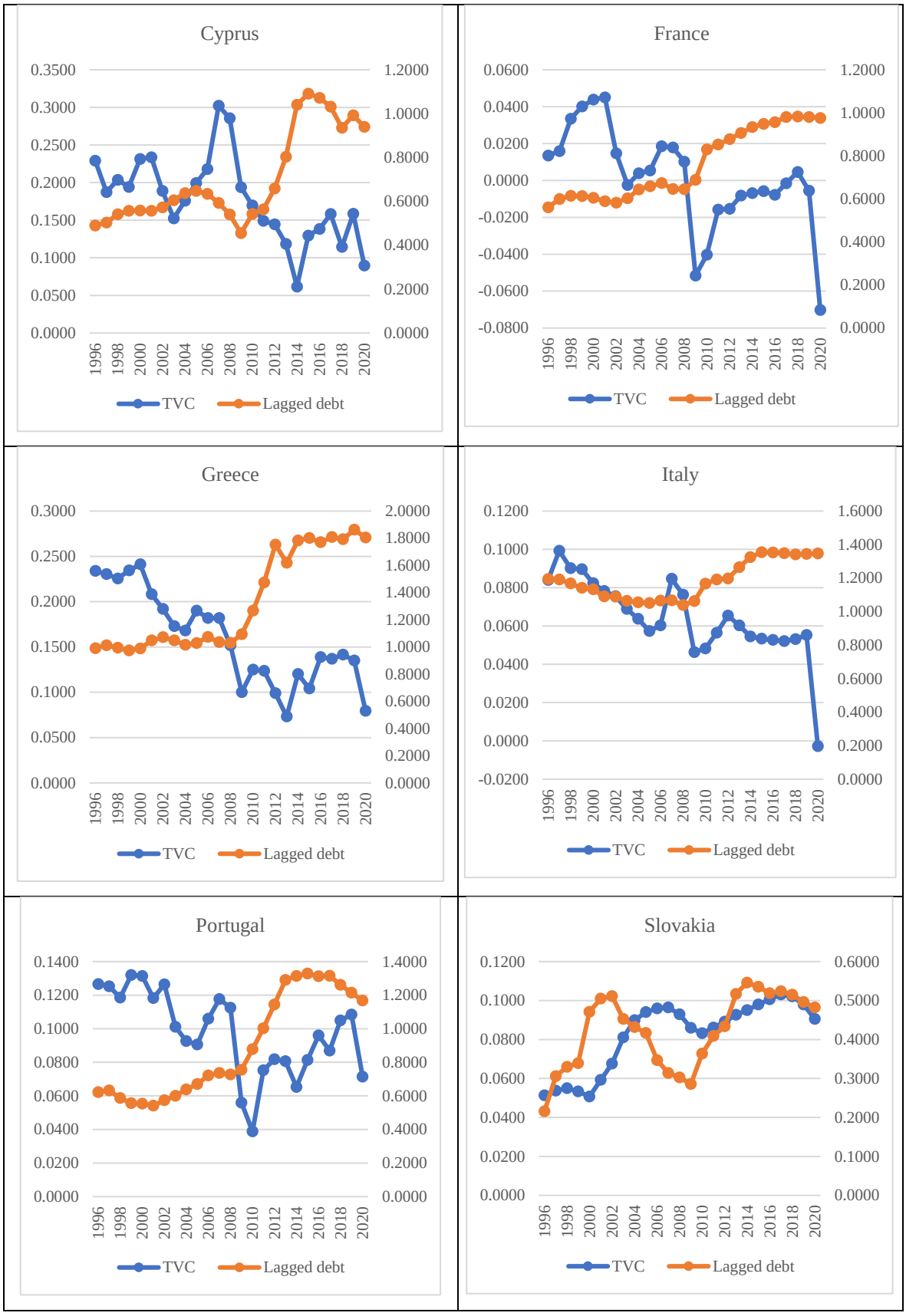
	d_TVC	GR	INF	TO	R	GB	CA	GOV	FR	D2010	RATING-M-A	RATING-M-B	RATING-SP-A	RATING-SP-B	RATING-F-A	RATING-F-B
d_TVC	1															
GR	0.159	1														
INF	0.219	0.244	1													
TO	-0.215	0.121	-0.046	1												
R	0.119	-0.312	-0.184	-0.226	1											
GB	-0.093	0.391	0.041	0.224	-0.383	1										
CA	-0.445	-0.209	-0.361	0.196	0.027	0.249	1									
GOV	-0.426	-0.078	-0.217	0.152	-0.135	0.303	0.490	1								
FR	-0.048	-0.038	-0.307	0.078	-0.287	0.317	0.402	0.095	1							
D2010	-0.077	-0.203	-0.367	0.200	-0.157	-0.094	0.287	-0.054	0.613	1						
RATING-M-A	-0.312	0.058	0.112	0.009	-0.295	0.342	0.264	0.664	-0.117	-0.398	1					
RATING-M-B	-0.304	0.071	0.115	0.016	-0.319	0.342	0.260	0.658	-0.112	-0.395	0.997	1				
RATING-SP-A	-0.335	0.024	0.019	0.067	-0.259	0.304	0.355	0.705	-0.123	-0.330	0.953	0.951	1			
RATING-SP-B	-0.335	0.024	0.019	0.067	-0.259	0.304	0.355	0.705	-0.123	-0.330	0.953	0.951	1.000	1		
RATING-F-A	-0.316	0.050	0.065	0.065	-0.280	0.341	0.302	0.686	-0.130	-0.365	0.970	0.971	0.968	0.968	1	
RATING-F-B	-0.313	0.053	0.067	0.066	-0.285	0.340	0.299	0.683	-0.130	-0.364	0.969	0.971	0.967	0.967	1	1

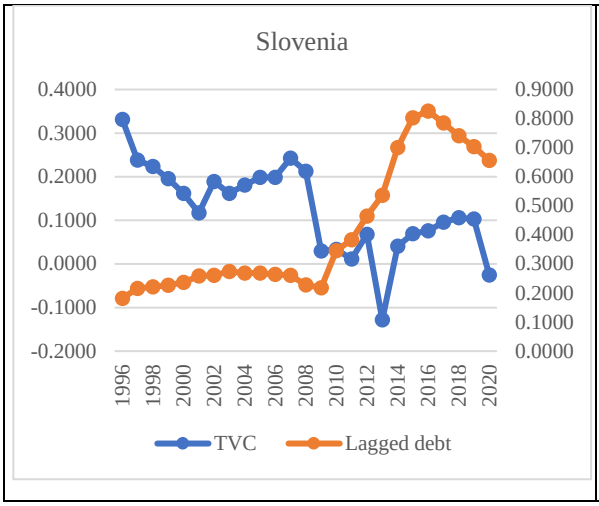
Table A5: Correlations between fiscal sustainability time-varying coefficients and the lagged public debt-to-GDP ratio, and the sovereign ratings (21-level scale)

Country	Lagged debt	Rating Moody´s	Rating S&P	Rating Fitch
Austria	-0.736	0.614	0.776	0.647
Belgium	0.371	0.545	0.454	-0.116
Cyprus	-0.678	0.747	0.688	0.695
Estonia	-0.759	N/A	-0.795	-0.459
Finland	-0.603	0.269	0.086	0.189
France	-0.579	0.393	0.389	0.359
Germany	0.081	N/A	N/A	N/A
Greece	-0.754	0.723	0.696	0.705
Ireland	0.569	-0.602	-0.568	-0.540
Italy	-0.468	0.541	0.677	0.678
Latvia	0.627	-0.251	0.116	-0.118
Lihuania	0.581	0.302	0.499	0.358
Luxembourg	0	N/A	N/A	N/A
Malta	-0.191	0.066	-0.573	-0.501
Netherlands	0.457	N/A	0.084	N/A
Portugal	-0.543	0.491	0.616	0.530
Slovakia	0.416	0.799	0.745	0.902
Slovenia	-0.575	0.646	0.636	0.583
Spain	0	0	0	0

Note: N/A: Not Available.
Source: Authors´ computations.

Figures A1-A7: Relationship between the fiscal sustainability time-varying coefficients and the lagged public debt-to-GDP ratio for some countries





Source: Own elaboration.