

Fiscal Sustainability in the EU

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Abstract We assessed the sustainability of fiscal policy in the 28 European Union countries over the 1980–2015 years. Panel unit root tests in the presence of cross-sectional dependence showed that government revenues, expenditures, the primary balance, and debt were non-stationary series. However, cointegration tests revealed that a long-run relationship exists between government revenues and expenditures as well as between government primary deficit and debt. The results of causality tests were in line with the neutrality hypothesis: government revenues do not cause the expenditures, and vice versa. Furthermore, mixture models analyses indicated the presence of three homogeneous clusters, one of which included Portugal, Ireland, Italy, Greece, and Spain (PIIGS), whose coefficient of 0.68 indicates the absence of sustainability, since government expenditures grow faster than revenues.

Keywords Fiscal sustainability · Public expenditure · Revenues · Primary deficit · Public debt · EU · Panel data

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Introduction

The sustainability of fiscal policies is a central topic with regard to both economics and public policy. The rise of public indebtedness of many industrial countries during the last decades of the twentieth century has caused increasing concern about its potentially

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unfavourable effects. Theoretically, equilibrium growth paths ought to be supported by adequate fiscal policy. Moreover, the European Union's (EU's) treaties impose the practical necessity of sustainable public accounts, keeping the public debt/gross domestic product (GDP) ratio below 60%, and the public deficit/GDP ratio below 3%. Such terms as fiscal space and the durability of fiscal policies have become increasingly important in the discussion of the rising debt to GDP ratios that limit the EU's ability to address the continuing political response to burdensome debt. Fiscal space reverses to the degree to which sovereign governments can implement changes in public sector tax and expenditure programs. The term is generalised with regard to prospects for government interventionist economic stimulus and economic development of specific sectors. Fiscal space is often used with regard to the overall macro economy and it is often used synonymously to mean a jump start of public and private sector programs (economic and regulatory reforms). Fiscal space is obviously a function of the degree of independence with regard to a country's external and domestic flexibility and the independence it may have to decide on its own government expenditures (Magazzino et al. 2015).

The degree of fiscal space available to a country is determined by the institutions that tax and raise public sector revenue as well as the level of existing public debt. Therefore, it is effective in stimulating an economic response. Debt levels and public finance parameters affect the management of trade-offs in the use of fiscal space. This is also subject to external or internal constraints such as economic and environmental regulations, ceilings on domestic and foreign borrowing, and limitations on the length of time and conditions imposed on arrears in debt repayment. Such factors limit a country's response and ability to innovate through such supply-side measures as tax reforms and reduction in government spending.

In general, fiscal space is the room and flexibility to make trade-offs by a government to implement a desired objective, such as economic recovery, reduction in unemployment, reduced government debt, or reduced debt-to-GDP ratio as required by various international programs (e.g., International Monetary Fund lending guidelines).

In discussing the elements of a constrained optimization exercise, we must emphasize the fiscal sustainability constraint; that these objectives be met and resolved without adversely affecting the country's financial position (internationally or as part of the EU) or the sustainability of the economy. Fiscal space may be enhanced by evaluating revenue sources, prioritizing expenditures, improving the incentives of programs, and enhancing the efficiency of tax revenue collection. Obviously, this is no small task and with multiple actors and often radically shifting objectives, the management of fiscal space is by its very nature a complex project fraught with numerous avenues for diversion and misadventure.

Efforts to address the increments of chronic public-sector debt by many industrial countries during the last decades of the twentieth century led to increasing concern about unfavourable effects on economic growth and political stability. This is understandable while in theory equilibrium growth paths ought to be supported by adequate, although politically determined, fiscal policy. Moreover, EU treaties impose the practical necessity of sustainable public accounts, keeping the public debt/GDP ratio below 60%, and the public deficit/GDP ratio below 3%. However, the lack of enforcement created difficulties in timely response to mounting criticism (internally and externally) of the debt positions of such countries as Portugal, Italy, Ireland, Greece and Spain (PIIGS).

Financial, economic, and sovereign crises of 2008-2010 have left a substantial tax burden for the governments of the Eurozone. The public debt-to-GDP ratio sharply rose as a direct consequence of the contraction of economic and countercyclical fiscal policies.

Moreover, sudden increases in government debt have adversely affected market confidence in government solvency and liquidity in several countries (Teică 2012).

The usual approach to analyzing the sustainability of fiscal policies implies stationarity and unit root tests for public debt and deficit, as well as cointegration tests between public expenditures and revenues. Sustainability of public debt means that accumulated public debt may be serviced at any time. This requires that governments must be solvent and liquid. In fact, if a government is literally insolvent, this presumably implies that it is currently unable to service its debt (Burnside 2005).

This paper adds to the existing literature by applying unit-root, stationarity and cointegration tests to the EU-28 countries over the period 1980-2015, using consistent public finance annual data from a unique source, the European Commission (1980-2015) Annual Macroeconomic Database (AMECO). Furthermore, we reach interesting results with the implementation of mixture models. Our approach emphasizes that fiscal sustainability and fiscal space are inextricably tied to a government's financial solvency.

At the beginning of the 1920s, when writing about the public debt problem faced by France, Keynes (1923) mentioned the need for the French government to conduct a sustainable fiscal policy in order to satisfy its budget constraint. Keynes stated that the absence of sustainability would be evident when "*the State's contractual liabilities [...] have reached an excessive proportion of national income*" (Keynes 1923, p. 54).

The sustainability of fiscal policy is sometimes associated with the financial solvency of the government. In practice, what the empirical literature ends up testing is whether both public expenditures and revenues may continue to display their historical growth patterns in the future. If a given fiscal policy turns out to be unsustainable, it has to change in order to guarantee that the future primary balances are consistent with the budget constraint. Theoretically, any value for the budget deficit would be possible if the government could raise its liabilities without limit. However, that is impossible, since the government is faced with the present value of its own budget constraint (Afonso 2005).

Theoretical Framework and Empirical Literature

Fiscal sustainability can be achieved through a complex mix of fiscal and budgetary policies, which aims to manage budgetary shortfalls and increase primary surpluses coupled with the additional constraint of monetary policy measures to ensure stability. In addition to major exogenous economic shocks, domestic and international politics makes this a very complicated constrained optimization problem.

Recalling the present value budget constraint (PVBC), it is possible to present analytically two definitions of sustainability suitable for empirical testing (Hamilton and Flavin 1986):

- (i). The value of current public debt equals the sum of future primary surpluses.
- (ii). The present value of public debt approaches zero in infinity.

To test the absence of Ponzi games, we inspect the stationarity of the first difference of the stock of the public debt ($\Delta GGGD_t$), and cointegration between the primary

balance, ($GGNPL$), and the (lagged) stock of the public debt ($GGGD_{t-1}$) (Bohn 2007; Afonso and Jalles 2015):

$$GGNPL_t = \alpha + \beta GGGD_{t-1} + u_t. \quad (1)$$

This ‘backward-looking’ approach implies that past increases in the level of public debt would imply larger primary balances today. Moreover, Trehan and Walsh (1991) observe that the stationarity of the variation in public debt stock is a sufficient condition. Stationarity rejection does not necessarily imply the absence of sustainability in the public accounts.

It is also possible to assess sustainability through cointegration between government revenues, GGR_t , and expenditures, $GGTE_t$. The implicit hypothesis concerning the real interest rate is also stationarity. With the no-Ponzi game condition, $GGTE_t$ and GGR_t must be cointegrated variables of order one for their first differences to be stationary. The procedure involves testing the following cointegrating regression:

$$GGR_t = \alpha + \beta GGTE_t + u_t \quad (2)$$

and if the null of no cointegration is rejected, u_t must be stationary. When GGR and $GGTE$ are non-stationary, cointegration is a necessary condition for the government to obey its PVBC (Hakkio and Rush 1991).

Several conclusions concerning the inter-temporal budget constraint may then be established:

- When there is no cointegration, the fiscal deficit is not sustainable.
- When there is cointegration with $\beta = 1$, the deficit is sustainable.
- When there is cointegration with $\beta < 1$, public expenditure grows faster than revenues, and the deficit may not be sustainable.

As concerns the applied studies on fiscal solvency of EU member states, Caporale (1995) tested the intertemporal balancing of the government budget in ten EU countries, finding that the government cannot be considered intertemporally solvent in Denmark, Germany, Greece and Italy. Vanhorebeek and van Rompuy (1995) focused on the fiscal solvency of eight EU countries during the period 1970-1994. On the basis of the empirical findings, only France and Germany seemed to obey the solvency criterion. Artis and Marcellino (1998) used data on debt and deficit ratios to test the long-run sustainability condition for 13 EU countries.

There appears to be ample fiscal space for reducing debt, promoting economic growth, and restoring fiscal sustainability. In general, the empirical findings demonstrate that fiscal sustainability does not hold. Papadopoulos and Sidiropoulos (1999) examined the stationarity of the public deficit for five EU economies. The results support the occurrence of sustainable deficits for the Greek, Spanish, and Portuguese economies. On the contrary, Italy and Belgium may incur unsustainable deficits.

Uctum and Wickens (2000) studied the conditions for determining the sustainability of fiscal policy in 11 EU countries and in the USA in the years 1965-1994. On the basis of infinite horizon-tests, the broad conclusion was that many countries do not have a sustainable policy. However, when future fiscal consolidation plans were considered, the empirical evidence changed. Bravo and Silvestre (2002) tested the sustainability of public deficits for

the period 1960–2000 in 11 EU member states. The applied results showed sustainable budgetary paths in Austria, France, Germany, the Netherlands and UK.

Kollias and Paleologou (2006) investigated the revenue-expenditure nexus for EU-15 using a vector error-correction model (VECM) methodology. The empirical tests yielded mixed results. Afonso (2005) analysed the fiscal sustainability of the EU-15 countries for the 1970–2013 period. With few exceptions, the empirical results showed that fiscal policy may not have been sustainable.

Greiner et al. (2007) studied the sustainability of fiscal policy for the Economic Monetary Union (EMU) countries that either have a high debt/GDP ratio or recently violated the deficit's rule of the Maastricht Treaty. The econometric findings showed that fiscal policies were sustainable. Izák (2009) analyzed public finances in ten post-socialist members of the EU. The empirical results showed that an increase in the growth rate of 1 percentage point would reduce the unit cost of debt by more than 30 basis points.

Afonso and Rault (2010) evaluated the sustainability of public finances in the EU-15 over the 1970–2006 period. Based on stationarity tests of government debt, the solvency condition was satisfied for seven EU countries: Austria, Finland, France, Germany, the Netherlands, Sweden, and the UK. Ahmad and Fanelli (2014) assessed the fiscal sustainability of ten Eurozone member countries. The results indicated that only three countries (Germany, Finland and Austria) show characteristics of medium-term fiscal sustainability. Five countries (France, Ireland, the Netherlands, Portugal and Spain) appeared to be weakly sustainable, meaning that, without a change in fiscal policy and taking structural actions, their positions may deteriorate. Two countries (Belgium and Italy) appeared to be structurally unsustainable due to their large accumulated stock of debt.

Esposito (2015) proposed a model for public debt sustainability and sovereign credit risk in the Eurozone. Magazzino and Lepore (2015) examined the effects of large budgetary policy manoeuvres among the 18 EMU members, in the period 1980–2015. Empirical evidence shows that in the case of a fiscal stimulus, a reduction in the tax burden and an increase in capital public expenditure generate an economic growth increase and an improvement in public finances, while the rise in current expenditure has the opposite effect. In the case of fiscal consolidation, a reduction in the current public expenditure compared to an increase in the tax burden is the most effective result, increasing the GDP growth rate. Forte and Magazzino (2016) evaluated fiscal adjustments that occurred in the 18 EMU countries from 1980 to 2015, showing that adjustments, such as cutting current expenditures rather than increasing taxes, are more likely to boost economic growth. On the contrary, cuts to investment expenditures might imply a GDP reduction.

Methodology and Data

Cross-sectional dependence in macro panel data has received a lot of attention in the emerging panel time series literature over the past decade. This type of correlation may arise from globally common shocks with heterogeneous impact across countries, such as the oil crises in the 1970s or the global financial crisis from 2007 onwards. Alternatively, cross-sectional dependence can be the result of local spillover effects between countries or regions (Eberhardt and Teal 2011; Moscone and Tosetti 2009). The Pesaran (2004) cross-sectional dependence test evaluates the correlation coefficients between the time-series for each panel member. Under the null hypothesis of cross-sectional independence, the above statistics are distributed

standard normal for $T_{ij} > 3$ and N is sufficiently large. The test is robust to nonstationarity (the spuriousness would show up in the averaging), parameter heterogeneity or structural breaks and performs well even in small samples. An interesting feature of this test is that, as Chudik and Pesaran (2015) demonstrate the implicit null hypothesis of the cross-sectional dependence (CD) test is, in the most common cases, the weak cross-sectional dependence of errors in the panel regression compared with the alternative of strong error cross-sectional dependence. This assumption makes the test more appealing from an applied perspective because when estimating a model, only strong cross-sectional correlation may pose serious problems or inconsistency of estimation.

A standard assumption in panel-data models is that the error terms are independent across cross sections. This assumption is used for identification purposes rather than descriptive accuracy. In the context of large T and small N , the Lagrange multiplier (LM) test statistic (Breusch and Pagan 1980) can be used to test for cross-sectional dependence. However, cross-sectional time-series datasets usually come in the form of small T and large N . In this case, the Breusch-Pagan test is not valid.

The Pesaran (2007) t -test for unit roots in heterogenous panels with cross-sectional dependence is based on the mean of individual Dickey-Fuller (DF) (or augmented Dickey-Fuller (ADF)) t -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 DF (or ADF) regressions are augmented with the cross-sectional averages of lagged levels and first-differences of the individual series (cointegrated augmented Dickey-Fuller (CADF) statistics). Lags of the dependent variable may be introduced to control for serial correlation in the errors. Pesaran's CADF test is consistent under the alternative that only a fraction of the series are stationary.

Furthermore, we run the Pedroni (2004) seven test statistics under a null of no cointegration in a heterogeneous panel (medium to large N , large T) with one or more non-stationary regressors. Two classes of statistics are considered. The first is based on pooling the residuals of the regression along the within-dimension of the panel. The second is based on pooling the residuals of the regression along the between-dimension of the panel. The Kao (1999) test is also constructed using the same approach as the Pedroni (2004) test but specifies cross-sectional intercepts and homogenous coefficients in the first stage regression. The null and alternative hypotheses are similar to those of Pedroni's test. The causality test developed by Dumitrescu and Hurlin (2012), which can return successful results even under the conditions of cross-sectional dependence, was used for the analysis.

Finally, regression mixture models are a tool to investigate population heterogeneity. This application of regression mixture modeling to an actual data set indicated that multiple latent classes might be embedded within the single regression functional form. Compared to conventional regression analysis that assumes one equation would fit all countries, a regression mixture analysis can provide a detailed description of sub-populations of countries within a sample. Thus, regression mixture models may improve predictability because the country-specific differences are systematically classified to form homogeneous groups.

Our study uses the AMECO Database of the European Commission (1980-2015) Directorate General for Economic and Financial Affairs (DG ECFIN). We collected data on government revenues (GGR), expenditures ($GGTE$), net primary lending ($GGNPL$), and gross debt ($GGGD$) for the 28 EU countries over the 1980-2015 period. Our analysis provides new evidence for the fiscal sustainability of these countries.

We applied the test to the above-mentioned variables in terms of GDP ratios, because several researchers (Hakkio and Rush 1991; Afonso 2005; and Bohn 2005) are of the view that analyses based on GDP-ratios provide more credible information about the fiscal series than the raw and real data. In addition, Online Supplemental Figs. 1 and 2 contain a graphical description of the data, while the Online Supplemental Appendix Table 1 presents the exploratory data analysis.

Empirical Results

A standard assumption in panel data models is that the error terms are independent across cross-sections. Cross-sectional dependence can arise due to a variety of factors, such as omitted observed common factors, spatial spillover effects, unobserved common factors, or general residual interdependence, all of which could remain even when all observed and unobserved common effects have been taken into account. For the EMU sample, some possible cross-country dependence can be envisaged in the presence of similar policy measures, fiscal behaviour, and cross-country spillover government bond markets (Afonso and Rault 2010).

Table 1 depicts the results of panel cross-sectional dependence tests, both for the EU-28 and EMU. The null hypothesis (H_0) is cross-sectional independence. For all variables, we broadly reject the null hypothesis at any level of significance in each test, concluding that cross-sectional dependence should be taken into account in our analysis. These results are valid for both samples (EU-28 and EMU).

To eliminate this type of dependence, the standard DF (or ADF) regressions were augmented with the cross-sectional averages of lagged levels and first differences of the individual series ("second generation" tests). Controlling for cross-sectional dependence, we do not clearly reject the null hypothesis that all series are non-stationary, for either the specification with the constant or for the one with the constant and trend (Table 2).

Thus, the outcome for the full sample is as follows: the null hypothesis of unit roots for the panel for total government revenues, expenditures, primary balance, and debt cannot be rejected with the variables in levels. Afonso and Rault (2010), assessing the sustainability of public finances in the EU-15 over the period 1970-2006, concluded that the stock of government debt series is integrated of order zero. Claeys (2007) found that European fiscal authorities maintained sustainable fiscal policies over the period 1970-2001. However, these results do not account for cross-sectional dependence.

Therefore, we implemented two panel cointegration tests. The first is that proposed by Pedroni (2004), a residual-based test for the null of no cointegration in heterogeneous panels; the second is the Kao (1999) test.

Table 3 shows the outcomes of the cointegration between total government revenues and expenditures, and the primary balance and lagged debt. We used four within-group tests and three between-group tests to check panel cointegration. The columns labelled within-dimension contain the computed value of the statistics based on estimators that pool the autoregressive coefficient across different countries for the unit root tests on the estimated residuals. The columns labelled between-dimension report the computed value of the statistics based on estimators that average individually calculated coefficients for each country. In general, we have a majority of tests for which the null hypothesis of no cointegration can be rejected (especially in the intercept-only specification). For both

Table 1 Panel cross-sectional dependence tests (EU-28, 1980-2015)

Variable	1	2	3	4	5
EU-28					
GGR	1889.819 (0.000)	54.984 (0.000)	54.584 (0.000)	1.510 (0.131)	2.331 (0.019)
GGTE	1730.930 (0.000)	49.206 (0.000)	48.806 (0.000)	20.169 (0.000)	19.721 (0.000)
GGNPL	1680.473 (0.000)	47.3705 (0.000)	46.9705 (0.000)	28.9759 (0.000)	22.026 (0.000)
GGGD	3072.198 (0.000)	97.987 (0.000)	97.587 (0.000)	32.356 (0.000)	18.181 (0.000)
EMU					
GGR	809.869 (0.000)	40.859 (0.000)	40.616 (0.000)	3.785 (0.000)	1.191 (0.233)
GGTE	770.938 (0.000)	38.499 (0.000)	38.256 (0.000)	14.319 (0.000)	17.137 (0.000)
GGNPL	641.852 (0.000)	30.672 (0.000)	30.429 (0.000)	17.345 (0.000)	13.043 (0.000)
GGGD	1163.164 (0.000)	62.281 (0.000)	62.038 (0.000)	24.297 (0.000)	13.191 (0.000)

Notes: 1: Breusch and Pagan (1980) LM; 2: Pesaran (2004) scaled LM; 3: Baltagi et al. (2012) bias-corrected scaled LM; 4: Pesaran (2004) CD; 5: Chudik and Pesaran (2015). *P*-values in parentheses. Tests include the intercept. Sources: our elaborations on AMECO data (European Commission 1980-2015).

samples, results show that the null hypothesis of no cointegration can be rejected. Therefore, the relationships identified in Eqs. 1 and 2 are cointegrated for the country sample panel.

Assuming that government revenues and expenditures (as well as government debt and primary balance) are cointegrated, we estimated the cointegrating coefficients to investigate the long-run relationship. In general, the results point to a positive long-run co-movement between the levels of government revenues and expenditures (Table 4). Moreover, for six countries the coefficient was not statistically significant (Bulgaria, Romania and Croatia, and 3 EMU countries: Belgium, Malta and Italy). Twenty-two countries showed a significant positive coefficient ranging from 0.27 (Lithuania) to 0.9308 (Poland). Only four of these countries had a coefficient value near 1 (Cyprus, Austria, Spain and Poland). The mean for

Table 2 Panel unit root tests in the presence of cross-sectional dependence (EU-28, 1980-2015)

Variable	Specification	
	Constant	Constant and trend
EU-28		
GGR	0.998 (0.841)	1.351 (0.912)
GGTE	0.787 (0.784)	1.793 (0.963)
GGNPL	1.524 (0.936)	3.282 (0.999)
GGGD	2.740 (0.997)	2.021 (0.978)
EMU		
GGR	1.390 (0.918)	0.468 (0.680)
GGTE	-0.216 (0.414)	0.752 (0.774)
GGNPL	0.682 (0.752)	2.148 (0.984)
GGGD	1.061 (0.856)	3.644 (1.000)

Notes: Pesaran's CADF test, *Z*-*t*-bar or *t*-bar statistics. *P*-values in parentheses

Sources: our elaborations on AMECO data (European Commission 1980-2015).

Table 3 Panel cointegration tests (EU-28, 1980-2015)

Pedroni's residual cointegration test					
Relation		GGR, GGTE		GGNPL, GGGD	
		Intercept	Intercept and trend	Intercept	Intercept and trend
EU-28					
Within-dimension	Panel ν	0.761 (0.223)	-0.719 (0.764)	2.623 (0.004)	-0.857 (0.804)
	Panel ρ	-2.844 (0.002)	-0.111 (0.456)	-2.717 (0.003)	-0.342 (0.366)
	Panel PP	-2.859 (0.002)	-1.989 (0.023)	-3.218 (0.001)	-2.048 (0.020)
	Panel ADF	-3.176 (0.001)	-2.542 (0.006)	-3.649 (0.000)	-3.186 (0.001)
Between-- dimension	Group ρ	-0.218 (0.414)	1.270 (0.898)	-0.752 (0.226)	1.616 (0.947)
	Group PP	-2.436 (0.007)	-3.071 (0.001)	-3.185 (0.001)	-2.340 (0.010)
	Group ADF	-3.171 (0.001)	-4.242 (0.000)	-5.148 (0.000)	-5.692 (0.000)
Kao's residual cointegration test					
	ADF	-3.233 (0.001)		-3.344 (0.000)	
EMU					
Within-dimension	Panel ν	0.683 (0.247)	-0.443 (0.671)	2.179 (0.015)	-0.194 (0.577)
	Panel ρ	-2.444 (0.007)	0.276 (0.609)	-2.264 (0.012)	-0.618 (0.268)
	Panel PP	-2.558 (0.005)	-1.377 (0.084)	-2.715 (0.003)	-2.098 (0.018)
	Panel ADF	-2.400 (0.008)	-0.980 (0.164)	-2.843 (0.002)	-2.611 (0.005)
Between-- dimension	Group ρ	-0.933 (0.175)	0.831 (0.797)	-1.182 (0.119)	0.603 (0.727)
	Group PP	-3.020 (0.001)	-2.952 (0.002)	-3.160 (0.000)	-3.051 (0.001)
	Group ADF	-2.862 (0.002)	-2.235 (0.013)	-4.590 (0.000)	-5.975 (0.000)
Kao's residual cointegration test					
	ADF	-1.831 (0.034)		-0.995 (0.160)	

Notes: P-values in parentheses

Sources: our elaborations on AMECO data (European Commission 1980-2015).

EMU countries is 0.54, very similar to that for non-EMU countries (0.57). In the second relationship, the average result points to solvency, although a country-by-country inspection shows that 18 countries (10 EMU members and 8 non-EMU) present significant positive coefficient estimates for the improvement of the primary balance after past debt increases. In

Table 4 Panel estimates of the cointegrating relationship fully modified ordinary least sequence (FMOLS) (EU-28, 1980-2015)

Country	GGR, GGTE	GGNPL, GGGD
Austria	0.8679*** (0.0975)	0.0317 (0.0842)
Belgium	0.0997 (0.1675)	0.1098*** (0.0331)
Cyprus	0.8546* (0.4492)	0.0774 (0.0679)
Estonia	0.6771*** (0.1205)	0.9007 (0.5661)
Finland	0.4147*** (0.0751)	0.1217* (0.0464)
France	0.5971*** (0.0985)	0.0247*** (0.0078)
Germany	0.3675** (0.1663)	0.0519** (0.0249)
Greece	0.6901* (0.3641)	0.0941** (0.0393)
Ireland	0.3957* (0.2297)	0.0023 (0.0153)
Italy	0.2150 (0.1471)	0.1034*** (0.0267)
Luxembourg	0.4132*** (0.1441)	0.1773 (0.2080)
Malta	-0.1678 (0.5536)	0.1801*** (0.0419)
Netherlands	0.3546** (0.1395)	0.0429 (0.0848)
Portugal	0.2846** (0.1332)	0.0115 (0.0162)
Slovakia	0.4388*** (0.0872)	0.0998* (0.0563)
Slovenia	0.3227*** (.0511)	0.0584* (0.0333)
Spain	0.8990*** (0.3265)	0.0658*** (0.0198)
Bulgaria	-0.2186 (1.1598)	0.0984*** (0.0336)
Czech Republic	0.3504*** (0.0833)	0.1212*** (0.0180)
Denmark	0.5792*** (0.1643)	0.0691 (0.0533)
Croatia	0.0940 (0.5082)	0.0997*** (0.0156)
Latvia	0.4285** (0.2005)	0.0352 (0.0293)
Lithuania	0.2709*** (0.0876)	0.0461 (0.0504)
Hungary	0.6674** (0.3421)	0.1109* (0.0609)
Poland	0.9308*** (0.3189)	0.1562*** (0.0574)
Romania	0.0783 (0.1526)	0.1782*** (0.0315)
Sweden	0.6811*** (0.1305)	0.0856*** (0.0290)
United Kingdom	0.6223*** (0.2388)	0.1148*** (0.0339)

Notes: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Sources: our elaborations on AMECO data (European Commission 1980-2015).

general, almost all countries exhibit one significant cointegrating relationship, 12 countries identify both relationships as statistically significant, seven for the EMU (Finland, France, Germany, Greece, Slovakia, Slovenia and Spain), and five for the others (Czech Republic, Hungary, Poland, Sweden and the UK).

The results of the Dumitrescu and Hurlin causality tests show the absence of any causality link between public expenditure and revenues for both EU-28 and EMU (Table 5). This is the institutional separation hypothesis or fiscal neutrality hypothesis introduced by Baghestani and McNown (1994), in which government revenue and expenditure are argued to be independent from each other due to the independent functions of the executive and legislative branches of the government. This perspective suggests that there is

Table 5 Panel pairwise causality tests (EU-28, 1980-2015)

EU-28		
Dumitrescu-Hurlin test	$GGTE_{it} \rightarrow GGR_{it}$ 0.2363 (0.8132)	$GGGD_{it} \rightarrow GGNPL_{it}$ 5.8496*** (0.0000)
Dumitrescu-Hurlin test	$GGR_{it} \rightarrow GGTE_{it}$ 1.0398 (0.2984)	$GGNPL_{it} \rightarrow GGGD_{it}$ 22.5402*** (0.0000)
EMU		
Dumitrescu-Hurlin test	$GGTE_{it} \rightarrow GGR_{it}$ 0.6746 (0.5000)	$GGGD_{it} \rightarrow GGNPL_{it}$ 3.7666*** (0.0002)
Dumitrescu-Hurlin test	$GGR_{it} \rightarrow GGTE_{it}$ 0.3810 (0.7032)	$GGNPL_{it} \rightarrow GGGD_{it}$ 23.4073*** (0.0000)

Notes: P-values in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Sources: our elaborations on AMECO data (European Commission 1980-2015).

no causality between revenues and expenditures, i.e., they are independent of each other. The executive and the legislative branches of the government are different institutions with different functions in the taxation and spending process. Therefore, since the decisions regarding expenditures and revenues are made by independent (or relatively separated) institutions, there should be no systematic causal ordering between them. Moreover, causality runs from lagged public debt to the primary balance, and vice versa. Bi-directional causality results both for EU-28 and EMU show that for this couple of variables a feedback effect emerges.

Finally, we estimated a finite mixture model (FMM) using public expenditures and revenues as variables of interest. The model selection criteria suggest the choice of three clusters. Two information criteria (Akaike information criterion (AIC) and adjusted Bayesian information criterion (BIC)) assume the lowest values with three components, and the likelihood is maximized with three-group clustering. In addition, the entropy measure assumes very similar values (Table 6). With three components, each group would include few observations.

The regression mixture analysis resulted in subgroups with specific regression function patterns (Table 7). In essence, the first cluster is formed by the Mediterranean and highly indebted EU members (note all 11 countries are in the Eurozone). The second group includes nine Northern and Continental countries. The last group combines eight Central and Eastern

Table 6 Penalized likelihood criteria (EU-28, 1980-2015)

K	2	3
l	763.890	772.802
AIC	-1513.780	-1523.604
BIC	-1481.893	-1473.496
Sample size adjusted BIC	-1504.119	-1508.423
Entropy	0.501	0.521

Notes: K : number of components; l : log-likelihood

Sources: our elaborations on AMECO data (European Commission 1980-2015).

Table 7 Finite mixture model (EU-28, 1980-2015)

Dependent variable: GGR		Coef. (SE)	
Component 1			
GGTE	0.6755*	(0.3845)	
Constant	0.7032	(0.4615)	
Component 2			
GGTE	0.9975***	(0.1029)	
Constant	0.9956	(0.7960)	
Component 3			
GGTE	0.9226***	(0.0636)	
Constant	0.7735	(0.9157)	
N	703		
Wald	675.41	(0.0000)	
σ_1	0.1135	(0.0193)	
σ_2	0.0518	(0.0217)	
σ_3	0.0012	(0.0004)	
Classification of subjects based on most likely latent class membership			
Component	Frequency	Percent	
1	302	42.96	
2	237	33.71	
3	164	23.33	
Average posterior probabilities			
Mean	Location 1	Location 2	Location 3
Probability 1	0.830	0.166	0.004
Probability 2	0.165	0.796	0.039
Probability 3	0.105	0.160	0.735

Notes: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Source: Own calculations using AMECO data (European Commission 1980-2015).

newcomer countries. In the first group, which includes the so-called PIIGS, the estimated coefficient is 0.68 ($p < 0.10$), indicating the absence of deficit sustainability, since government expenditures grow faster than revenues. Instead, the second group shows $\beta = 1.00$ ($p < 0.01$), which involves sustainability, with a bounded debt-to-GDP ratio (Table 8).

The three clusters seem to form homogeneous groups, considering public finance conditions and history. Moreover, this subdivision reflects the public debt stock of the countries in

Table 8 Country clusters: FMM panel estimates

Group 1	Group 2	Group 3
11: Belgium, Cyprus, France, Greece, Ireland, Italy, Malta, Portugal, Slovakia, Slovenia, Spain	9: Austria, Denmark, Finland, Germany, Luxembourg, Netherlands, Poland, Sweden, UK	8: Bulgaria, Czech Republic, Croatia, Estonia, Latvia, Lithuania, Hungary, Romania

each group, insofar as the most indebted EU members are located in group 1, while Eastern economies form group 3.

Concluding Remarks and Policy Implications

This study has extended research on the fiscal solvency of the EU and EMU countries. When speaking about solvency, economists refer to a government's ability to service its debt obligations without explicitly defaulting on them. We analyzed separately the EU-28 and the Eurozone samples. After checking for the presence of cross-sectional dependence, the results of second generation panel unit root tests conclude in favour of the non-stationarity of government revenues, expenditures, the primary deficit, and debt. Cointegration tests showed that a long-run relationship exists between government revenues and expenditures, but also between government primary deficit and debt. The panel estimates of the cointegrating relationships point to a positive long-run co-movement between government revenues and expenditures. Moreover, causality tests show the absence of any causal link between government revenues and expenditures both for the EU-28 and the EMU, supporting the fiscal neutrality hypothesis. Therefore, since the decisions regarding revenues and expenditures are made by independent (or relatively separated) institutions, there should be no systematic causal ordering between them. Furthermore, regression mixture analyses indicated the presence of three homogeneous clusters. Interestingly, the coefficient of the first group was 0.68, indicating the absence of sustainability, since government expenditures grew faster than revenues. This "non-virtuous" group included 11 EMU and EU member states. On the contrary, the second group coefficient was 1.00, which involves fiscal sustainability, with a bounded debt-to-GDP ratio. This "virtuous" group was formed by nine northern and continental economies.

These findings highlight the profound differences that exist among the various members of the Eurozone regarding public finances. This could represent not only a threat to the solvency of individual member countries, but also a danger to the fiscal sustainability of the whole area. In fact, the fiscal position of about 75% of the Eurozone is alarming, with public expenditures growing faster than revenues. In particular, the Mediterranean countries are dangerously exposed to the risk of speculative crises. Further research should examine the degree to which these countries are exposed to such risk.

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