Multi-step Analysis of Public Finances Sustainability

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Abstract

We use an original multi-step analysis to assess the sustainability of public finances. First, we investigate the mean-reverting behaviour of government expenditures and revenues. Second, we apply bootstrap panel cointegration techniques to check for a long-run relationship between expenditures and revenues. Third, we check the coefficient of expenditure in the cointegration relation. Fourth, we estimate panel error correction models to sort out short- and long-run fiscal developments. While results imply that public finances were not unsustainable for the EU panel, fiscal sustainability is an issue in most countries, with a below unit estimated coefficient of expenditure in the cointegration relation.

Keywords: fiscal sustainability, EU, panel cointegration.
JEL Classification Numbers: C23, E62, H62.

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1. Introduction

Studies on the sustainability of public finances regarding the European Union (EU) usually restrict themselves to the set of EU Member States before the 1 May 2004 enlargement. To our knowledge, this is the first fully fledged panel analysis of fiscal sustainability encompassing this enlarged set of EU countries. The choice of such group of countries is usually prompted by the lack of longer comparable time series data for the new EU Member States. In this paper we assess the sustainability of public finances, taking advantage of non-stationary panel data econometric techniques as well as the Pooled Mean Group (PMG) estimation method (see e.g. Pesaran and Smith, 1995; Pesaran, Shin and Smith, 1999), and the Common Correlated Effect (CCE) estimator (Pesaran, 2006, allowing for common factors in the cross equation covariances to be removed), covering several sub-periods within the period 1960-2012 and also defining different country groupings for the 27 members of the EU.

Even if there is no single fiscal policy in the EU, panel analysis of the sustainability of public finances is relevant in the context of 27 EU countries seeking to pursue sound fiscal policies within the framework Stability and Growth Pact. Cross-country dependence can be envisaged either in the run-up to EMU or, for example, via integrated financial markets. Indeed, cross-country spillovers in government bond markets are to be expected, and interest rates comovements inside the EU have also gradually become more noticeable. On the other hand, and since fiscal sustainability certainly needs to be tackled at the country level, a country assessment is also necessary, being therefore useful to have as many time series observations as possible. In this context, the use of the Seemingly Unrelated Regression ADF (SURADF) panel integration test provides additional country specific results.

In the literature, fiscal sustainability analysis based on unit root or cointegration tests has in the past been mostly performed for individual countries posing the problem of relatively short time series.[1] Usually, such country analysis tends to reject less the sustainability hypothesis for a few developed economies, notably Germany (allowing for the reunification break), Netherlands, Finland, and Austria, and the U.K., even if the time span can be an issue for some studies (see Fève and Hénin, 2000, Uctum and Wickens, 2000, and Afonso, 2005, Blackley, 2009).

However, panel data methods have recently been used to assess fiscal sustainability, notably when testing for cointegration between general government expenditure and revenue – a relationship derived from the intertemporal government budget constraint. In this context panel unit root and panel cointegration analysis have been used, for instance, by Prohl and Schneider (2006) for the EU, Westerlund and Prohl (2006), for OECD countries, Afonso and Rault (2007, 2010), and Afonso and Jalles (2012) for the EU. Apart from the already mentioned cross-country dependency issue, another argument for using this approach is the increased power that may be brought to the cointegration hypothesis through the increased number of observations that results from adding the individual time series.

In this paper we contribute to the literature by proposing a multi-step empirical methodology to assess the sustainability of public finances in the EU. First, the SURADF panel integration test from Breuer et al. (2002, 2006) is implemented for the general government expenditures and revenues series as a ratio of GDP. To the best of our knowledge, this is the first empirical application of the test in the context of fiscal sustainability. This test accounts for cross-sectional dependence among countries and allows to identify how many and which countries of the panel have a unit root, which has the advantage of considering the possibility of cross-section dependence but still provides country specific sustainability assessments.

[1] See, for instance, Hakkio and Rush (1991), Haug (1991), Quintos (1995), and Ahmed and Rogers (1995).

Second, for the countries for which spending and revenues are found to be integrated of order one, we then carry out the panel bootstrap test of Westerlund and Edgerton (2007) that tests for the null hypothesis of cointegration between the two sides of the budget against the alternative that there is at least one country for which the two variables are not cointegrated.

Third, if cointegration is not found, long-run fiscal sustainability is rejected, whereas if cointegration is found, the testing proceeds by checking with the CCE procedure of Pesaran (2006) (that allows for cross-section dependencies), for a unit slope on spending in a regression of revenues on spending. The latter is a necessary condition for the long-run sustainability of public finances to hold.

Fourth, another important issue is how to model the reduced form relationship in the presence of possible non-stationarity in the panel. Indeed, a cursory reading of the formal literature on government spending and borrowing in stochastic general equilibrium suggests that given the panel data employed, there could also be short-run cyclical effects of relevance, which may vary across countries. Thus, in order to address this issue we employ the Pooled Mean Group approach of Pesaran, Shin and Smith (1999) to sort out the long-run versus short-run effects of the EU member states respective fiscal policies. The advantage of such approach is that it not only informs about the issue of unit-roots in the country panel but also allows for short-run versus long-run analyses of fiscal sustainability in the same specification. Individual countries may well be on the same long-run path albeit with different short-run developments.

The rest of the paper is organised as follows. Section Two briefly presents the analytical framework for fiscal sustainability. Section Three explains our econometric strategy. Section Four reports the empirical fiscal sustainability results for the EU, following our multi-step analysis, and Section Five concludes.

2. Analytical framework for fiscal sustainability

The starting point for the analysis of the sustainability of public finances is the so-called present value borrowing constraint, derived from the flow budget constraint (see Hakkio and Rush, 1991, and Afonso, 2005), and can be written for a given country as

$$B_{t-1} = \sum_{s=0}^{\infty} \frac{1}{(1+r)^{s+1}} (R_{t+s} - E_{t+s}) + \lim_{s \to \infty} \frac{B_{t+s}}{(1+r)^{s+1}} \qquad (1)$$

where $E_t = GP_t + (r_t - r)B_{t-1}$, with GP_t - primary government expenditure R_t - government revenue, B_t - government debt at the end of t, r - real interest rate, assumed to be stationary with mean r. A sustainable fiscal policy needs to ensure that the present value of the stock of government debt, the second term of the right-hand side of (1), reaches zero at infinity, constraining the debt to grow no faster than the real interest rate. The existence of this no-Ponzi game condition also implies that the outstanding stock of government debt equals the present value of future government surpluses. From (1), and defining $G_t = GP_t + r_t B_{t-1}$, we have, after some manipulations,

$$G_t - R_t = \sum_{s=0}^{\infty} \frac{1}{(1+r)^{s-1}} (\Delta R_{t+s} - \Delta E_{t+s}) + \lim_{s \to \infty} \frac{B_{t+s}}{(1+r)^{s+1}}. \qquad (2)$$

Using GDP ratios, with the GDP real growth rate, y, also assumed constant, we have, after some manipulations,

$$b_{t-1} = \sum_{s=0}^{\infty} \left(\frac{1+y}{1+r} \right)^{(s+1)} \left[\rho_{t+s} - e_{t+s} \right] + \lim_{s \to \infty} b_{t+s} \left(\frac{1+y}{1+r} \right)^{(s+1)}, \qquad (3)$$

with $b_t = B_t/Y_t$, $e_t = E_t/Y_t$ and $\rho_t = R_t/Y_t$. When $r > y$, the solvency condition

$$\lim_{s \to \infty} b_{t+s} \left(\frac{1+y}{1+r} \right)^{(s+1)} = 0 \qquad (4)$$

is needed to limit public debt growth (the inequality in this case would be a suboptimal result for the government).

With the no-Ponzi game condition, that is, with the second term of the right-hand side of (1) and (2) converging to zero, G_t and R_t must be cointegrated of order one for their first differences to be stationary. If R and E are non-stationary, and the first differences are stationary, then R and E are I(1) in levels. Thus, for (3) to hold, its left-hand side, in other words the budget balance, will also have to be stationary, which is possible if G and R are integrated of order one, with cointegration vector (1,-1). Therefore, assessing fiscal sustainability involves testing the cointegration regression, notably as GDP ratios:

$$R_t = a + \beta G_t + u_t . \qquad (5)$$

Naturally, and as mentioned, for instance, by Afonso (2005), if one of the two variables is I(0) and the other is I(1) there may be a sustainability issue, and more precisely, this can not be tested via cointegration. On the other hand, it may also be the case that even with different orders of integration there are no sustainability problems if revenues are systematically above expenditures and the country consistently runs a budgetary surplus.[2]

The non-Ponzi condition has to be seen, in the context of panel, has relevant for the entire panel. Therefore, the overall fiscal position of the set of EU countries considered would be sustainable is spite of some problems in some countries.

3. Econometric strategy

3.1. Methodological issues

The literature on panel unit root and panel cointegration distinguishes between first generation tests developed on the assumption of the cross-sectional independence among panel units (except for common time effects), and second generation tests allowing for a variety of dependence across the different units.

Although panel data unit root tests are likely to have higher power than conventional time series unit root tests, by including cross-section variations (which make them very popular in applied studies), their results must, however, be interpreted with some caution,

[2] Another theoretical avenue would be the estimation of so-called ad-hoc fiscal reaction functions, where usually the primary balance depends on government debt (see, for instance, Bohn, 1998, 2007).

especially when testing for the sustainability of fiscal policy. In particular, as noted by Taylor and Sarno (1998) and Taylor and Taylor (2004), when there is the possibility of a mixed panel, for example, when some of the members may be stationary while others may be non-stationary, then the null and alternative hypotheses are less suitable. Indeed, rejection of the unit root null in the panel does not imply that stationarity holds even for the majority of the members in the panel. The most that can be inferred is that at least one country is mean reverting or that stationarity holds only marginally for a few countries. In the context of fiscal sustainability and in economic terms this would imply that the stock of general government debt is stationary for at least one country even though public finances may not be sustainable for the majority of the countries in the panel sample.

However, researchers sometimes tend to draw a much stronger inference that, for instance, when in a given panel sample all government debt series are mean reverting, hence claiming to provide evidence supporting fiscal sustainability, which is not necessarily valid. Instead, for mixed panels, under most interpretations the preferred positioning of the null hypothesis would be "stationarity holds for all members of the panel" against the alternative that "stationarity fails for at least some members of the panel". This would allow testing how pervasive the fiscal sustainability condition is for any given group of countries. One way to do this would be to use a panel test for the null of stationarity (see e.g. Hadri, 2000, whose null hypothesis is stationarity).

Another way to address this issue would be to use a procedure allowing to identify how many and which panel members are responsible for rejecting the joint null of non-stationarity. For example, Breuer et al. (2002, 2006) advocate a procedure whereby unit root testing is conducted within a Seemingly Unrelated Regression (SUR) framework, which exploits the information in the error covariance to produce efficient estimators and potentially more powerful test statistics. A further advantage of this procedure is that the SUR framework is another useful way of addressing cross-sectional dependency. We will pursue this second option in this paper, in what consists of step one of our empirical methodology.

Like most panel data unit root tests that are based on the null hypothesis of joint non-stationarity (against the alternative that at least one panel member is stationary), the well-known panel cointegration tests developed by Pedroni (1999, 2004), generalized by Banerjee and Carrion-i-Silvestre (2006) are of the null of joint non-cointegration. The problem here is that a single series from the panel might be responsible for rejecting the joint null of non-stationary or non-cointegration, hence not necessarily implying that a cointegration relationship holds for the whole set of countries. In addition, such panel tests for the null hypothesis of no cointegration have been criticized in the literature because it is usually the opposite null that is of primary interest in empirical research. A possible way to overcome this difficulty is to implement the bootstrap panel cointegration test proposed by Westerlund and Edgerton (2007) where the null hypothesis is cointegration which implies, if not rejected, the existence of a long-run relationship for all panel members, and potential fiscal sustainability (the alternative hypothesis being that there is no cointegrating relationship for at least one country of the panel). The Westerlund and Edgerton (2007) test relies on the popular Lagrange multiplier test of McCoskey and Kao (1998), and permits correlation to be accommodated both within and between the individual cross-sectional units.

Afterwards, we assess the magnitude of the β coefficient in the cointegration regression via the computation of new common correlated effect CCE and CCE-MG (Mean Group) estimators (Pesaran, 2006), our step three. Finally, we estimate panel ECM (PECM) models with the Pooled Mean Group approach of Pesaran, Shin and Smith (1999), which allows us to assess the adjustment mechanism to a deviation from the long-run equilibrium relationship along with the short-run dynamics, our step four.

3.2. Series specific panel unit root test: SURADF

The SURADF test developed by Breuer et al. (2002, 2006) is based on the following system of ADF equations:

$$\begin{cases} \Delta y_{1,t} = \alpha_1 + \phi_1 y_{1,t-1} + \sum_{i=1}^{p_1} \gamma_{1,i} \Delta y_{1,t-i} + \varepsilon_{1,t} \quad t = 1,\ldots,T \\ \Delta y_{2,t} = \alpha_2 + \phi_2 y_{2,t-1} + \sum_{i=1}^{p_2} \gamma_{2,i} \Delta y_{2,t-i} + \varepsilon_{2,t} \quad t = 1,\ldots,T \\ \ldots \\ \Delta y_{N,t} = \alpha_N + \phi_N y_{N,t-1} + \sum_{i=1}^{p_N} \gamma_{N,i} \Delta y_{N,t-i} + \varepsilon_{N,t} \quad t = 1,\ldots,T \end{cases} \tag{6}$$

where $\phi_j = (\rho_j - 1)$ and ρ_j is the autoregressive coefficient for series j (j=1,...N). This system is estimated by the SUR procedure and the null and the alternative hypotheses are tested individually as:

$$\begin{cases} H_0^1 : \phi_1 = 0; \quad H_A^1 : \phi_1 < 0 \\ H_0^2 : \phi_2 = 0; \quad H_A^2 : \phi_2 < 0 \\ \ldots \\ H_0^N : \phi_N = 0; \quad H_A^N : \phi_N < 0 \end{cases} \tag{7}$$

with the test statistics computed from SUR estimates of system (6) while the critical values are generated by Monte Carlo simulations. This procedure has three advantages. First, by exploiting the information from the error covariances and allowing for autoregressive process, it leads to efficient estimators over the single-equation methods. Second, the estimation also allows for heterogeneity in the lag structure across the panel members. Third, the SURADF panel integration test accounts for possible cross-sectional dependence among countries and allows to identify how many and which countries of the panel have a unit root.

4. Investigating fiscal sustainability in the EU

All data for general government expenditure and revenue are taken from the European Commission Annual Macro-Economic Data (AMECO) database.[3] The data cover the periods 1960-2012 for the EU15 countries, 1998-2012 for the EU25 countries, and 2000-2012 for the EU26 countries, in order not to consider two countries with the smallest number of observations in the sample. The second sub-period covers the period after the setting of the Economic and Monetary Union, the last period zooms in more on the years before, during and after the 2008-2009 economic and financial crisis.[4]

4.1. Step 1: unit root analysis

There are good reasons to believe that there is considerable heterogeneity in the countries under investigation and thus the typical panel unit root tests may lead to misleading inferences. Besides, the rejection of the null hypothesis that all series have a unit root doesn't imply that under the alternative all series are mean-reverting since there may be a mixture of stationary and non-stationary processes in the panel under the alternative hypothesis. However, in case of the rejection of the null, for instance the conventional Im, Pesaran and Shin (2003) or by Breitung (2000) tests, do not provide us with information about the exact mix of series in the panel, that is, for which series in the panel the unit root is rejected and for which it is not. The SURADF test proposed by Breuer et al. (2002, 2006) addresses this issue.

Another advantage is that the SUR framework is a useful way of addressing cross-sectional dependency. To test for the presence of such cross-sectional dependence we have implemented the simple test of Pesaran (2004). This test is based on the average of pair-wise correlation coefficients of the OLS residuals obtained from standard augmented Dickey-Fuller

[3] The AMECO codes are: general government total expenditure (% of GDP), .1.0.319.0.UUTGE, .1.0.319.0.UUTGF; general government total revenue (% of GDP), .1.0.319.0.URTG, .1.0.319.0.URTGF.
[4] EU15 includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Spain, United Kingdom, and Sweden, EU25 excludes Bulgaria and Slovenia, and EU26 excludes Bulgaria, the countries with the smaller number of observations.

regressions for each individual. Its null hypothesis is cross-sectional independence and is asymptotically distributed as a two-tailed standard normal distribution. Results available upon request indicate that the null hypothesis is always rejected regardless of the number of lags included in the augmented DF auxiliary regression (up to five lags) at the five percent level of significance.[5]

In the context of our paper, cross-dependence can mirror possible changes in the behaviour of fiscal authorities related to the signing of the EU Treaty in Maastricht on 7 February 1992. The setting up of the fiscal convergence criteria that urged the EU countries to consolidate public finances from the mid-1990s onwards in the run-up to the EMU on 1 January 1999, when most EU legacy currencies were replaced by the euro, and more recently the adoption of the EU fiscal framework by the New Member States.

As the SURADF test has non-standard distributions, the critical values need to be obtained via simulations. In the Monte Carlo simulations, the intercepts, the coefficients on the lagged values for each series, were set equal to zero in each of the three EU15, EU25 and EU26 panel sets (see Breuer et al., 2002, 2006). In what follows, the lagged differences and the covariance matrix were obtained from the SUR estimation on the general government expenditure and revenue ratio series. The SURADF test statistic for each series was computed as the t-statistic calculated individually for the coefficient on the lagged level. To obtain the critical values, the experiments were replicated 10,000 times and the critical values of five per cent were tailored to the number of countries considered in the three panel sets.[6]

As is now well known, the presence of cross-section dependence renders the ordinary least squares estimator inefficient and biased, which makes it a poor candidate for inference. A common approach to alleviate this problem is to use seemingly unrelated regressions

[5] Pesaran's CD test statistics vary from 12.21 to 31.36 depending on the series under investigation and is always highly significant at any conventional level of significance (the P-value being equal to zero in all cases). This provides evidence in favor of the existence of strong cross-sectional dependence in the data.

[6] We are grateful to Myles Wallace for providing us the SURADF Rats codes that we adapted here for our purpose.

techniques. However, as noted by Westerlund (2007), this approach is not feasible when the cross-sectional dimension N is of the same order of magnitude as the time series dimension T, since the covariance matrix of the regression errors then becomes rank deficient. In fact, for the SUR approach to work properly, one usually requires T being substantially larger than N, a condition that is fulfilled for our EU15 panel, but not for the EU25 and EU26 panels. As a consequence, for the last two panels the SURDAF test is actually performed on the (unbalanced) 1960-2012 period, according to data availability.

The results of the SURADF test are reported in Tables 1 and 2, respectively for the general government revenue and expenditure ratios. As indicated in Table 1, at the five per cent level of significance the null hypothesis of non-stationarity of the general government revenue-to-GDP ratios can only be rejected in one country (Poland) for the EU25 and EU26 panel sets.[7]

[Table 1]

Moreover, according to the SURADF tests in Table 2, the general government expenditure-to-GDP ratios are non-stationary in most countries, but the null of a unit root can be rejected at the five per cent level of significance in one country (Germany) for the EU15 panel, and in four countries (Estonia, Hungary, Poland and Slovakia)[8] for the EU25 and EU26 panels.[9]

[Table 2]

[7] Testing with one and ten per cent critical values provided similar results.

[8] We have also checked, using the Seemingly Unrelated Regressions Augmented Dickey-Fuller test, that the first differences of revenues and expenditures are stationary for all members of the three panel sets, hence confirming that the series in level are at most integrated of order one.

[9] The simulations provided by Breuer et al. (2002) demonstrate that the SURADF tests provide increased power over the single equation Dickey–Fuller tests when residual cross-correlations are high as it is the case in our country sustainability analysis. Indeed, the SUR estimators exploit the information in the error covariances to produce efficient estimators. This is not be the case of the conventional country-specific ADF tests, which we also implemented for comparison purpose, and that were unable to reject the individual unit root (under the null) for each country of our three panel sets (results are available on request). Consequently, it is useful to move to SURADF tests that lead here to new insights.

Indeed, there are good reasons to believe that, over the time period considered, these two ratios have exhibited non-stationary behaviour in these countries. For the general government spending and revenue-to-GDP ratios, we consider a time period during which the size of government increased in most OECD countries and, is some cases, some decoupling took place between spending and revenue ratios giving rise to persistent fiscal imbalances. Hence, the finding that both ratios exhibit unit root properties is also economically reasonable. Therefore, not accounting for unit root properties of fiscal ratios might thus lead to spurious regressions.

As an additional check of whether the finding of non-stationarity of the ratios is reasonable for the considered countries, we have tested for the existence of a cointegrating relationship between the general government revenue and expenditure, on the one hand, and GDP, on the other hand. Finding that the components of the respective ratios are cointegrated would indicate that the ratios themselves are stationary. In unreported regressions, we cannot find evidence for cointegration between general government revenue and GDP, nor between general government expenditure and GDP, which supports our failure to reject that the ratios are non-stationary.

In sum, the results of the panel unit root tests of the individual time-series suggest that the general government revenue and expenditure ratios should be treated as non-stationary series in most countries of our sample.

4.2. Step 2: panel cointegration

Given the results of the SURADF tests we define three new panel sets: EU14 which includes all countries of the EU15 panel except Germany; EU21 and EU22 which correspond to the EU25 and EU26 previous panel sets without Estonia, Hungary, Poland and Slovakia.

Indeed, in these countries, at least one of the two series of general government revenue and expenditure is integrated of order zero, hence preventing us from carrying out cointegration techniques. We then perform 2nd generation panel data cointegration tests, between government expenditure and revenue, which allow for cross-sectional dependence among countries.[10]

More specifically, we use the bootstrap panel cointegration test of Westerlund and Edgerton (2007). Unlike the panel data cointegration tests of Pedroni (1999, 2004), generalized by Banerjee and Carrion-i-Silvestre (2006), this test has the advantage that the joint null hypothesis is cointegration. Therefore, in case of null non-rejection we know for sure that a cointegration relationship exists for the full set of countries of the panel set, which is crucial here to assess fiscal sustainability.[11]

The results, reported in Table 3 for a model including a constant term indicate the absence of a cointegrating relationship between government revenue and expenditure for the EU14 and for the EU21 panels since with an asymptotic p-value of 0.00 the null hypothesis of cointegration is rejected, in line with the results of Afonso and Rault (2010) for a shorter panel sample.

[Table 3]

However, an opposite and more encouraging result is obtained for a model including a constant if one refers to the bootstrap critical values (which are valid here given the high degree of cross-section dependence found in the data with the CD statistic of Pesaran, 2004), indicating that for the usual significance levels, the null hypothesis is now not rejected for the period 1960-2012. Hence at the conventional five and ten per cent levels of significance, we can conclude that a cointegration relationship exists between government revenue and expenditure ratios for the three panel data sets.

[10] We previously found significant evidence of cross-sectional dependence it in the data.
[11] This bootstrap test is based on the sieve-sampling scheme, with the advantage of significantly reducing the distortions of the asymptotic test. We are grateful to Joakim Westerlund for sending us his Gauss codes.

Interestingly, and since the two last panel sets start essentially at the end of the 1990s, this evidence regarding the existence of a long-run relationship between government revenue and expenditure is rather in line with the results from Afonso and Rault (2010) for the EU15, for the sub-period 1992-2006 (even if for a smaller set of countries). Such results can be reasoned as an increased awareness of policymakers after that period to redress public finances in order to prepare for stage three of the Economic and Monetary Union, which started on 1 January 1999.

Moreover, the fact that in the EU panel one would not reject the hypothesis of fiscal sustainability is welcomed and puts into perspective the eventual individual difficulties that carry out decentralised fiscal policies. Indeed, this is important for notably two reasons. First, the size of government indebtedness in the EU (or in the euro area) is not bigger than say the case of the US of Japan. Second, in the context of the 2010-2011 European sovereign debt crisis fiscal policy started being individually less decentralised, with the European institutions taking more ownership of country level fiscal policy. Therefore, the path to a more centralised fiscal policy implementation in the euro area is reinforced with the results that show the absence of fiscal un-sustainability in the overall EU panels.

4.3. Step 3: the magnitude of the cointegration relationship

We estimate for each country the cross-section augmented cointegrating regression

$$R_{it} = \alpha_i + \beta_i G_{it} + \mu_{1i} \overline{R}_t + \mu_{2i} \overline{G}_t + u_{it},\ i = 1,...N;\ t = 1,...,T \quad (8)$$

for the three panel sets to assess the magnitude of the individual β_i coefficient in the cointegrating relationship with the CCE estimation procedure developed by Pesaran (2006), which addresses cross-sectional dependency. The regression includes the cross-section averages of the dependent variable and the observed regressors as proxies for the unobserved factors. Accordingly, $\overline{R}_t$ and $\overline{G}_t$ denotes respectively the cross-section averages of R_i, and G_i in year t.[12] The estimation results are reported in Table 4.

[Table 4]

According to our estimation results, although the coefficient β is almost always statistically significant, and with the right sign, its magnitude is also below unity. Nevertheless, it seems fair to point out that the size of the β coefficient is quite high in some cases and consistently close or above, for instance, 0.9, notably for Denmark, Germany, Portugal, the Netherlands, and the U.K. These results, which mostly hold for all three country panels that we studied, can be read as an indicator that public finances may have been less unsustainable in the past for the abovementioned countries.

On the other hand, it is also possible to observe the lower magnitude of the estimated β coefficient for several countries such as Belgium, Greece, Ireland, Italy, Portugal, or France, which reflects a bigger departure from a one-to-one linkage between expenditures and revenues in the cointegration relationship. Interestingly, and as a result of running significant budget deficits, most of those countries also experienced a divergent behaviour of their respective debt-to-GDP ratio during continued phases in the sample period, which would theoretically increase in infinite horizon if the magnitude of β were to remain too far away and below unity. Indeed, the expenditure ratios were systematically above, and growing faster in some cases than the revenue ratios, for most of the period in Belgium, Greece, Ireland, and Italy. Some of those countries also experienced important fiscal deteriorations in the aftermath of the 2007-2008 economic and financial crisis, and following the 2010 sovereign debt crisis.

[12] We also compute the CCE-MG estimators of Pesaran (2006), and for β and its standard error, for N cross-sectional units, they are obtained as $\hat{\beta}_{CCE-MG} = \sum_{i=1}^{N} \hat{\beta}_{i-CCE} / N$ and $SE(\hat{\beta}_{CCE-MG}) = \sum_{i=1}^{N} \sigma(\hat{\beta}_{i-CCE}) / \sqrt{N}$, where $\hat{\beta}_{i-CCE}$ and $\sigma(\hat{\beta}_{i-CCE})$ denote respectively the estimated individual country time-series coefficients and their standard deviations.

On the other hand, in Finland and in Sweden that difference was particularly acute in the first half of the 1990s (when the two countries faced important fiscal deteriorations).

The common correlated effects mean group (CCE-MG) method yields the following results (t-statistics are in parentheses):

EU14 panel (1960-2012)

$$\underset{(7.85)}{R_{it} = 1.085} + \underset{(3.98)}{0.73G_{it}} + \underset{(6.45)}{0.76\overline{R}_t} - \underset{(-5.53)}{0.46\overline{G}_t}, \quad (8a)$$

EU21 panel (1960-2012)

$$R_{it} = \underset{(10.27)}{2.78} + \underset{(4.98)}{0.85G_{it}} + \underset{(7.47)}{0.36\overline{R}_t} - \underset{(-4.75)}{0.23\overline{G}_t}, \quad (8b)$$

EU22 panel (1960-2012)

$$R_{it} = \underset{(12.01)}{2.95} + \underset{(6.02)}{0.88G_{it}} + \underset{(8.32)}{0.47\overline{R}_t} - \underset{(-3.38)}{0.29\overline{G}_t} \quad (8c)$$

We further investigate whether public finances were sustainable for the above models using a Student test statistic to test whether the panel cointegration coefficient of the general government expenditure-to-GDP ratio is equal to one in the cointegrating regression where revenue is the dependent variable. Over the 1960-2012 periods and for the EU14 panel data set the calculated Student test statistic is of 1.47 with an associated p-value of 14.16 %, which provides evidence in favour of the null of a common unit slope equal to one, at the ten percent level of significance. Evidence of the sustainability of public finances is obtained for the EU21 and EU22 panel data set over the 1998-2012 and 2000-2012 periods since the calculated Student test statistic for the above hypothesis are respectively of 0.87 and 0.82, the associated p-values being respectively of 38.43 and 41.22%.

4.4. Step 4: Estimation of a panel ECM (PECM) representation

Having established in the previous step the long-run structure of the underlying data, and given that there exists a long-run relationship for all countries in our three panel sets, we now estimate the complete panel error-correction model (PECM) described by:

$$\Delta R_{it} = \sum_{j=1}^{p} \Gamma_{1j}\, \Delta R_{it-j} + \sum_{j=0}^{p} \Gamma_{2j}\, \Delta G_{it-j} + \lambda_i \left[R_{it-1} - \alpha - \beta G_{it-1} \right] + \varepsilon_{it},\ i = 1,\ldots,N;\ t = 1,\ldots,T \quad (9)$$

We use the Pooled Mean Group (PMG) approach of Pesaran, Shin and Smith (1999), with long-run parameters obtained with CCE techniques, in order to obtain the estimates of the loading factors λ_i (weights or error correction parameters, or speed of adjustment to the equilibrium values), as well as of the short-run parameters Γ_{1j} and Γ_{2j} for each country of our panel. Consequently, the loading factors and the short-run coefficients are allowed to differ across countries.[13]

The lag length structure p is chosen using the Schwarz (SC) and Hannan-Quinn (HQ) selection criteria, and by carrying out a standard likelihood ratio testing-down type procedure to examine the lag significance from a long-lag structure (started with $p=5$) to a more parsimonious one. Afterwards, in order to improve the statistical specification of the model, we implemented systematically Wald tests of exclusion of lagged variables from the short-run dynamic (they are not reported here) to eliminate insignificant short-run estimates at the 5% level. We tested the residuals from each PECM model for the absence of heteroscedasticity, autocorrelation, ARCH effect, and we can report that they are not subject to misspecification. The results of the PECM estimations based on (9) for the three panel sets are reported in Table 5, only for significant short-run estimates at the 5% level.

[Table 5]

[13] Note that before considering equation (9), we first used a Wald statistic to test for common parameters across countries (i.e $\lambda_i = \lambda$, and $\beta_i = \beta$, for i=1,...,N) with the CCE techniques of Pesaran, (2006), that allow common factors in the cross-equation covariances to be removed. And we found that only the $\beta_i = \beta$, for i=1,…, N was not rejected by the data, whereas speeds of adjustment λ_i vary considerably across countries (results are available upon request).

According to Table 5, there is mostly a short-run positive response of government revenue to government spending in the EU14 panel set, with changes in the revenue ratio following contemporaneous changes in the spending ratio. One exception is Finland where only the lagged response is not statistically positive.

For the more country comprehensive panel sets, the results are broadly similar with a stronger short-run contemporaneous responsiveness of government revenues to government spending in the cases of Denmark, France, Germany, Ireland, Netherlands, Spain and UK. On the other hand, such response has a lower magnitude in the case of Belgium, Greece, Italy, Portugal, and Sweden, flagging again some unwelcome fiscal dynamics for these countries. These results are rather in line with the conclusions from the previous section where we estimated the long-run parameters and the cointegration relationships. Therefore, in this final step of our sustainability analysis we are able to gain insight both on the existence of a long-run relationship between the two sides of the general government budget, and also on the short-run dynamics ruling fiscal behaviour across these countries, which is also an addition to existing results.

5. Conclusion

Even in the absence of a single fiscal policy in the EU, panel analysis of fiscal sustainability is certainly relevant in the context of 27 EU countries seeking to pursue sound fiscal policies within the framework of the Stability and Growth Pact. In this paper, starting from the intertemporal government budget constraint, and taking advantage of non-stationary panel data econometric techniques we assessed the sustainability of public finances covering several sub-periods within the period 1960-**2012** and also defining different country groupings for the 27 members of the EU.

More specifically, we proposed and implemented an original multi-step analysis comprising: (i) SURADF panel integration analysis (that tests for individual unit root within the panel member and handles heterogeneous serial correction across panel members), the first empirical application in the context of the sustainability of public finances; (ii) panel bootstrap to test the null hypothesis of cointegration between expenditure and revenue ratios; (iii) test for cross-section dependencies (potentially arising from multiple unobserved common factors); (iv) panel error correction models of the revenue ratios, where short- and long-run effects are estimated jointly from a general autoregressive distributed-lag model, and where the short-run effects vary across countries. This multi-step approach takes advantage of the increased power of panel techniques and also provides specific information regarding how far from fiscal sustainability a given country has been in the past.

According to the results, notably with the SURADF test, general government revenue and expenditure-to-GDP ratios are not stationary for the overwhelming majority of the EU27 countries. Additionally, at the conventional five per cent levels of significance, we can also conclude that there exists a cointegrating relationship between government revenue and expenditure ratios for the EU14 panel data set over the period 1960-2012. A similar conclusion regarding the existence of a cointegration relation can be drawn for the country panel sets that include the more recent members of the EU: EU21, for the period 1998-2012; and EU22, for the period 2000-2012.

Moreover, and even if a co-integration vector was identified for all countries, the estimated coefficient for expenditures, in the co-integration equations is usually less than one. In other words, for the period 1960-2012, we conclude that government expenditures in the EU countries exhibited a higher growth rate than public revenues, questioning the hypothesis of fiscal policy sustainability. These results suggest that fiscal policy may not have been sustainable for most countries while it may have been less unsustainable for such countries as

Denmark, the Netherlands, and Spain, being also consistent with the ones from the panel error-correction model used in step four of our analysis. Therefore, policymakers in most EU countries need to ensure that notably government spending growth rates are curbed to avoid running in the future into unpleasant fiscal sustainability pitfalls.

Overall, and while the results imply that public finances were not unsustainable for the EU panels, some country diversity emerged. Indeed, while a higher degree of fiscal sustainability was found for the cases of Denmark, Germany, the Netherlands, and Spain, somewhat opposite conclusions were also uncovered for Belgium, Greece, Italy, Portugal, and Sweden.

Finally, the use of the panel error correction model also permits uncovering a stronger short-run contemporaneous response of government revenues to government spending in the cases of Denmark, France, Germany, Ireland, Netherlands, Spain and UK. Such behaviour of the respective budgetary components naturally helped increasing past fiscal sustainability for these countries.

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Table 1 – SURADF stationarity tests with critical values for general government revenue-to-GDP ratios

	Test statistic			5% critical value		
	EU15 1/	EU25 2/	EU26 3/	EU15	EU25	EU26
Austria	-2.99	-4.18	-4.19	-5.09	-11.16	-12.23
Belgium	-3.16	-2.75	-2.73	-5.140	-11.02	-11.98
Cyprus		-1.44	-1.49		-10.14	-11.45
Czech Republic		-1.89	-1.90		-11.12	-12.45
Denmark	-3.39	-2.68	-2.97	-5.19	-10.87	-11.95
Estonia		-5.96	-6.12		-11.54	-12.54
Finland	-2.71	-2.56	-2.61	-5.55	-10.92	-11.93
France	-1.74	-2.88	-2.87	-5.15	-10.86	-11.99
Germany	-3.15	-5.18	-5.21	-4.77	-10.76	-11.79
Greece	-0.94	-0.98	-1.06	-5.46	-10.87	-11.88
Hungary		-0.97	-0.99		-11.33	-12.76
Ireland	-3.97	-4.09	-4.12	-5.65	-11.22	-12.34
Italy	-1.47	-1.46	-1.43	-5.46	-11.09	-11.87
Latvia		-3.78	-3.76		-12.89	-14.12
Lithuania		-2.28	-2.29		-12.34	-13.87
Luxembourg	-2.44	-4.27	-4.29	-5.78	-11.88	-13.35
Malta		-0.65	-0.67		-12.17	-13.21
Netherlands	-4.66	-4.42	-4.37	-5.81	-13.49	-14.67
Poland		-11.12*	-11.06*		-12.29	-11.46
Portugal	-0.88	-1.09	-1.14	-5.66	-14.12	-15.34
Romania		-8.05	-8.76		-13.55	-14.92
Slovakia		-4.81	-4.88		-12.57	-13.86
Slovenia			-1.04			-14.26
Spain	-0.81	-2.86	-2.98	-5.17	-13.87	-15.17
Sweden	-2.87	-3.99	-4.12	-5.65	-14.34	-15.67
United Kingdom	-2.76	-5.71	-5.77	-5.78	-14.32	-15.55

The SURADF column refers to the estimated Augmented Dickey–Fuller statistics obtained through the SUR estimation associated to the three EU15, EU25 and EU26 ADF regressions. Each of the estimated equation includes a constant but not a time trend. The three right-hand side columns contain the estimated critical values tailored by the simulation experiments based on 10,000 replications, following the work by Breuer et al. (2002). The symbols *, **, and *** denote statistical significant at the 10%, 5% and 1% level respectively. E25 excludes Bulgaria and Slovenia; E26 excludes Bulgaria. Note that for each country we test for individual unit root (under the null) within the panel members.
1/ 1960-2012; 2/ 1998-2012; 3/ 2000-2012.

Table 2 – SURADF stationarity tests with critical values for general government expenditure-to-GDP ratios

	Test statistic			5% critical value		
	EU15	EU25	EU26	**EU15**	**EU25**	**EU26**
Austria	-2.61	-3.85	-2.71	-5.65	-11.98	-12.32
Belgium	-3.07	-5.18	-2.83	-5.127	-11.34	-11.48
Cyprus		-4.56	-0.37		-10.67	-11.87
Czech Republic		-0.98	-3.19		-11.45	-12.88
Denmark	-4.57	-2.77	-3.22	-5.48	-11.34	-12.26
Estonia		-13.76***	-11.58**		-10.97	-10.29
Finland	-2.27	-1.49	-2.32	-4.99	-11.86	-10.67
France	-1.47	-3.25	-2.90	-4.57	-11.54	-12.14
Germany	-4.96*	-7.92	-6.44	-5.12	-11.61	-12.34
Greece	-1.97	-2.39	-2.56	-5.77	-12.31	-12.45
Hungary		-9.66*	-9.77*		-10.34	-10.97
Ireland	-3.34	-4.92	-2.87	-5.62	-12.88	-12.09
Italy	-2.97	-3.85	-2.95	-5.88	-12.86	-13.66
Latvia		-0.57	-3.42		-12.34	-12.87
Lithuania		-5.15	-1.92		-11.82	-13.65
Luxembourg	-2.36	-2.88	-3.34	-5.77	-10.56	-13.33
Malta		-3.14	-0.95		-10.94	-11.81
Netherlands	-4.66	-9.56	-3.92	-5.61	-12.94	-14.44
Poland		-10.88*	-9.60*		-11.46	-10.43
Portugal	-1.27	-4.77	-2.97	-5.69	-12.56	-13.94
Romania		-2.64	-7.07		-10.92	-9.78
Slovakia		-16.89***	-11.61*		-11.69	-12.71
Slovenia			-3.49			-10.36
Spain	-2.58	-5.41	-3.59	-6.12	-13.34	-14.28
Sweden	-3.42	-5.71	-4.81	-6.142	-12.56	-14.23
United Kingdom	-3.60	-1.75	-2.97	-5.77	-11.66	-6.98

The SURADF column refers to the estimated Augmented Dickey–Fuller statistics obtained through the SUR estimation associated to the three EU15, EU25 and EU26 ADF regressions. Each of the estimated equation includes a constant but not a time trend. The three right-hand side columns contain the estimated critical values tailored by the simulation experiments based on 10,000 replications, following the work by Breuer et al. (2002). The symbols *, **, and *** denote statistical significant at the 10%, 5% and 1% level respectively. E25 excludes Bulgaria and Slovenia; E26 excludes Bulgaria. Note that for each country we test for individual unit root (under the null) within the panel members.
1/ 1960-2012; 2/ 1998-2012; 3/ 2000-2012.

Table 3 – Panel cointegration test results between government revenue and expenditure (Westerlund and Edgerton, 2007) [a]

	LM-stat	Asymptotic p-value	Bootstrap p-value
EU14 (1960-2012)			
Model with a constant term	4.478	0.000	0.724
EU21 (1998-2012)			
Model with a constant term	4.799	0.000	0.670
EU22 (2000-2012)			
Model with a constant term	1.153	0.239	0.876

Note: the bootstrap is based on 2000 replications. a - The null hypothesis of the tests is cointegration between government revenue and expenditure. E14 excludes Germany, vis-à-vis the initial EU15 set; E21 excludes Bulgaria, Estonia, Hungary, Poland, Slovakia, and Slovenia; E22 excludes Bulgaria, Estonia, Hungary, Poland, and Slovakia. 1/ 1960-2012; 2/ 1998-2012; 3/ 2000-2012.

Table 4a – Individual Country CCE Estimates for the EU14 panel (1960-2012)

Country	β	t-Stat	α	t-Stat	μ_1	t-Stat	μ_2	t-Stat
Austria	0.623	7.506	7.240	7.982	0.416	5.403	-0.186	-2.241
Belgium	0.363	4.271	-0.067	-0.034	1.143	6.684	-0.471	-2.232
Denmark	0.837	3.430	-3.956	-0.939	1.346	5.472	-0.995	-2.926
Finland	0.301	7.000	-6.003	-5.712	1.065	12.831	-0.109	-1.185
France	0.503	7.738	6.897	9.320	0.562	6.690	-0.203	-2.030
Greece	0.706	10.537	3.404	1.564	1.177	5.605	-1.061	-7.688
Ireland	0.235	1.469	0.466	0.107	0.720	1.841	-0.111	-0.275
Italy	0.540	1.475	-6.093	-1.645	1.199	4.282	-0.671	-1.410
Luxemburg	0.661	4.896	-2.751	-1.363	0.571	3.120	-0.158	-0.756
Netherlands	0.913	19.021	-0.816	-0.604	0.726	7.333	-0.628	-5.761
Portugal	0.887	12.493	3.136	1.443	0.849	6.197	-0.870	-8.286
Spain	0.737	11.338	-1.665	-0.836	1.093	5.280	-0.847	-5.923
Sweden	0.521	7.041	13.691	8.873	1.039	9.445	-0.686	-7.072
UK	0.539	3.327	9.543	2.118	0.794	3.254	-0.594	-2.192

Table 4b – Individual Country CCE Estimates for the EU21 panel (1960-2012)

Country	β	t-Stat	α	t-Stat	μ_1	t-Stat	μ_2	t-Stat
Austria	0.795	29.444	6.800	6.989	0.434	6.200	-0.375	-5.597
Belgium	0.561	11.220	4.625	2.302	0.902	8.275	-0.504	-4.893
Cyprus	0.918	25.500	-6.545	-4.114	1.385	5.496	-1.089	-5.472
Czech Republic	0.840	25.455	-3.998	-2.003	0.533	1.897	-0.365	-1.798
Denmark	0.970	12.436	-0.567	-0.397	1.530	4.873	-1.385	-4.074
Finland	0.635	5.670	8.577	3.640	0.385	1.005	-0.087	-0.195
France	0.369	2.976	19.444	5.198	-0.181	-0.751	0.394	1.576
Germany	0.969	12.750	3.484	1.960	0.578	4.661	-0.669	-4.848
Greece	0.425	3.899	2.033	1.763	1.417	8.097	-0.926	-4.952
Ireland	0.487	2.799	6.189	0.912	0.856	1.106	-0.553	-0.722
Italy	0.381	5.080	2.542	1.021	0.623	4.099	-0.060	-0.405
Latvia	0.895	18.646	-5.380	-2.362	1.090	3.123	-0.843	-3.043
Lithuania	0.811	26.161	-5.648	-3.639	0.885	4.917	-0.641	-4.856
Luxembourg	0.979	11.253	0.989	0.422	0.412	1.338	-0.353	-1.213
Malta	0.906	60.400	1.392	1.548	-0.305	-1.525	0.241	1.497
Netherlands	0.926	27.235	-0.195	-0.156	0.895	7.716	-0.809	-6.915
Portugal	0.550	5.500	-0.905	-0.777	0.909	7.390	-0.492	-2.718
Romania	0.853	37.087	-3.075	-2.567	0.661	3.046	-0.521	-3.083
Spain	0.864	13.714	1.650	1.846	1.352	6.347	-1.264	-5.402
Sweden	0.644	10.915	16.088	7.698	1.009	6.959	-0.845	-6.402
UK	0.715	4.387	8.499	1.528	0.929	2.781	-0.864	-2.526

Table 4c – Individual Country CCE Estimates for the EU22 panel (1960-2012)

Country	β	t-Stat	α	t-Stat	μ_1	t-Stat	μ_2	t-Stat
Austria	0.796	31.840	6.829	7.128	0.445	6.357	-0.387	-5.954
Belgium	0.579	11.580	4.856	2.382	0.907	7.956	-0.531	-5.057
Cyprus	0.909	23.921	-6.466	-4.054	1.437	5.702	-1.130	-5.707
Czech Republic	0.834	25.273	-4.135	-2.163	0.559	2.055	-0.378	-1.919
Denmark	0.968	13.829	-0.425	-0.297	1.565	4.875	-1.417	-4.155
Finland	0.671	6.156	8.828	3.544	0.428	1.086	-0.174	-0.391
France	0.385	3.438	19.355	5.461	-0.217	-0.868	0.415	1.667
Germany	0.956	14.708	3.525	2.116	0.606	5.411	-0.683	-5.991
Greece	0.464	4.377	3.044	2.955	1.401	7.413	-0.971	-4.737
Ireland	0.517	3.059	6.251	0.918	0.965	1.181	-0.686	-0.852
Italy	0.432	6.000	2.768	1.113	0.627	3.800	-0.120	-0.779
Latvia	0.908	17.804	-4.181	-1.808	1.069	3.020	-0.859	-2.952
Lithuania	0.808	25.250	-5.361	-3.630	0.895	4.812	-0.651	-4.717
Luxembourg	0.999	12.183	0.871	0.377	0.443	1.443	-0.400	-1.413
Malta	0.900	56.250	0.883	1.079	-0.267	-1.290	0.221	1.308
Netherlands	0.926	28.061	-0.094	-0.075	0.918	7.714	-0.832	-7.051
Portugal	0.590	6.629	0.108	0.121	0.919	6.910	-0.561	-3.082
Romania	0.848	35.333	-3.117	-2.673	0.697	3.242	-0.549	-3.287
Slovenia	0.913	65.214	-1.188	-1.256	0.418	2.080	-0.355	-2.191
Spain	0.864	15.158	1.643	1.996	1.407	6.700	-1.315	-5.819
Sweden	0.651	11.224	16.165	7.600	1.030	6.398	-0.874	-5.986
UK	0.737	4.494	7.960	1.415	0.984	2.903	-0.928	-2.682

Table 5a – Panel Error-Correction Estimations for R_{it} for the EU14 panel (1960-2012)

	ΔR_{it-1}	ΔR_{it-2}	ΔG_{it}	ΔG_{it-1}	ΔG_{it-2}	Loading factor λ_i	intercept	G_{it-1}
Austria	0.21	-0.23	0.10	-0.22		-0.49	1.09	0.63
	(2.95)	(-2.09)	(2.15)	(-2.14)		(-4.79)	(7.95)	(3.25)
Belgium			0.28			-0.08	1.02	0.62
			(4.02)			(-2.97)	(7.12)	(3.24)
Denmark	0.27		0.43	-0.45		-0.26	1.04	0.49
	(3.02)		(3.77)	(-3.24)		(-3.98)	(7.55)	(3.66)
Finland				0.11	-0.24	-0.17	1.05	0.64
				(2.33)	(-2.66)	(-2.38)	(7.21)	(4.02)
France			0.28			-0.37	1.06	0.61
			(5.17)			(-5.32)	(7.90)	(3.17)
Greece			0.11			-0.03	1.06	0.62
			(3.55)			(-2.98)	(7.35)	(3.45)
Ireland			0.02			0.36	1.11	0.64
			(1.98)			(4.22)	(7.98)	(3.92)
Italy			0.03			-0.03	1.08	0.60
			(2.36)			(-2.17)	(8.02)	(3.17)
Luxemburg			0.34	-0.23		-0.07	1.08	0.64
			(4.95)	(-3.34)		(-5.55)	(7.92)	(3.66)
Netherlands	0.35		0.09			-0.09	1.03	0.69
	(4.02)		(2.97)			(-4.87)	(7.72)	(4.28)
Portugal	0.06	-0.56	-0.09	0.36		-0.07	1.02	0.64
	(2.66)	(-4.28)	(-4.22)	(3.01)		(-7.93)	(7.34)	(3.65)
Spain	-0.44	0.32	0.11			-0.17	1.09	0.65
	(-4.68)	(2.57)	(3.75)			(-3.98)	(7.93)	(3.93)
Sweden	0.52		0.75	-0.46	-0.47	-0.31	1.07	0.63
	(3.28)		(3.87)	(-422)	(-2.48)	(-3.55)	(7.87)	(3.57)
UK			0.06			-0.17	1.08	0.65
			(2.62)			(-3.13)	(7.99)	(4.02)

Notes: The estimations are obtained from the Pooled Mean Group approach with long-run parameters estimated with CCE techniques. The coefficients of the variables $\overline{R}_t$ *and* $\overline{G}_t$ of equation (8a) have not been reported in the table. t-statistics are in brackets.

Table 5b – Panel Error-Correction Estimations for R_{it} for the EU21 panel (1960-2012)

	ΔR_{it-1}	ΔR_{it-2}	ΔG_{it}	ΔG_{it-1}	ΔG_{it-2}	Loading factor λ_i	intercept	G_{it-1}
Austria	0.24	-0.23	0.11	-0.26		-0.49	2.47	0.77
	(2.88)	(-2.12)	(3.14)	(-4.89)		(-5.09)	(9.56)	(4.43)
Belgium			0.04	0.27		-0.18	2.47	0.78
			(3.36)	(3.88)		(-4.17)	(9.65)	(4.76)
Cyprus	2.17	1.46	-2.87	-2.22	-1.58	-0.23	2.43	0.75
	(13.05)	(6.92)	(-8.22)	(-12.87)	(-7.14)	(-3.56)	(9.47)	(4.43)
Czech	0.14		0.05	-0.09		0.17	2.42	0.71
Republic	(2.38)		(3.23)	(-2.76)		(-2.36)	(9.55)	(4.01)
Denmark	0.29		0.42	-0.47		-0.30	2.44	0.75
	(2.25)		(3.98)	(-3.78)		(-5.76)	(9.89)	(4.39)
Finland			0.26	0.08	-0.22	1.09	2.45	0.72
			(2.12)	(2.77)	(-3.09)	(8.44)	(9.77)	(3.99)
France			0.27			0.39	2.45	0.73
			(4.34)			(4.92)	(9.99)	(4.17)
Germany	0.19		0.23			0.99	2.46	0.71
	(2.77)		(3.43)			(5.42)	(9.78)	(4.09)
Greece			0.09			-0.05	2.44	0.73
			(3.01)			(-3.34)	(9.65)	(4.195)
Ireland	-0.21	-0.24	0.39	-0.04	0.27	-0.07	2.45	0.77
	(-2.24)	(-2.87)	(3.76)	(-2.98)	(2.21)	(-3.34)	(9.76)	(4.99)
Italy			0.16			-0.05	2.42	0.75
			(3.99)			(-8.73)	(9.28)	(4.12)
Latvia			0.17	-0.14		-0.13	2.45	0.76
			(3.12)	(-3.96)		(-2.92)	(9.77)	(4.78)
Lithuania	-022	-0.45	0.29	0.17	0.19	-0.31	2.45	0.76
	(7.65)	(-20.76)	(9.36)	(6.56)	(10.65)	(-3.76)	(9.67)	(4.28)
Luxembourg			0.29			-0.18	2.45	0.77
			(2.43)			(-276)	(9.66)	(4.98)
Malta			0.36			0.08	2.54	0.76
			(3.98)			(3.56)	(9.782)	(4.67)
Netherlands			0.37			-0.23	2.46	0.75
			(3.98)			(-4.68)	(9.76)	(4.56)
Portugal	-0.08	-0.55	0.01	0.22		-0.10	2.44	0.75
	(-2.77)	(-3.98)	(2.13)	(3.09)		(-2.44)	(9.48)	(4.76)
Romania	0.11	-0.35	0.56	-0.09	0.25	0.09	2.44	0.73
	(245)	(-9.47)	(15.87)	(-2.44)	(7.76)	(6.92)	(9.77)	(4.12)
Spain			0.35			-0.04	2.44	0.74
			(3.67)			(-4.65)	(9.76)	(4.54)
Sweden	0.38		0.10	-0.17	-0.25	-0.35	2.44	0.74
	(2.34)		(2.22)	(-2.54)	(-3.87)	(-4.22)	(9.87)	(4.45)
UK	0.43		0.45	-0.41		-0.29	2.42	0.73
	(3.66)		(4.76)	(-3.22)		(-3.87)	(9.23)	(4.19)

Notes: The estimations are obtained from the Pooled Mean Group approach with long-run parameters estimated with CCE techniques. The coefficients of the variables $\overline{R}_t$ *and* $\overline{G}_t$ of equation (8b) have not been reported in the table. t-statistics are in brackets.

Table 5c – Panel Error-Correction Estimations for R_{it} for the EU22 panel (1960-2012)

	ΔR_{it-1}	ΔR_{it-2}	ΔG_{it}	ΔG_{it-1}	ΔG_{it-2}	Loading factor λ_i	intercept	G_{it-1}
Austria	0.17	-0.22	0.19	-0.176		-0.38	2.44	0.75
	(2.45)	(-2.23)	(3.33)	(-3.78)		(-4.17)	(11.68)	(4.27)
Belgium			0.07	0.27		-0.09	2.41	0.76
			(2.56)	(3.92)		(-2.27)	(11.01)	(4.46)
Cyprus	2.08	1.34	-2.72	-2.17	-1.55	-0.23	2.40	0.75
	(12.54)	(5.45)	(-7.68)	(-11.22)	(-6.13)	(-3.48)	(10.87)	(4.08)
Czech	0.17		0.06	-0.13		0.18	2.44	0.76
Republic	(2.67)		(3.14)	(-3.23)		(-3.96)	(11.66)	(4.78)
Denmark	0.27		0.33	-0.53		-0.26	2.41	0.76
	(2.12)		(2.75)	(-3.87)		(-5.65)	(10.88)	(4.45)
Finland			0.26	0.07	-0.21	1.04	2.40	0.73
			(3.23)	(2.56)	(-3.12)	(7.23)	(11.00)	(4.08)
France			0.23			0.36	2.45	0.76
			(4.43)			(3.77)	(11.76)	(4.26)
Germany	0.19		0.28			0.98	2.48	0.75
	(2.66)		(3.97)			(5.09)	(11.87)	(4.13)
Greece			0.12			-0.06	2.41	0.72
			(3.98)			(-3.13)	(10.96)	(4.13)
Ireland	-0.19	-0.25	0.37	-0.09	0.29	-0.06	2.44	0.76
	(-2.67)	(-3.07)	(3.56)	(-4.08)	(2.94)	(-3.54)	(11.78)	(4.12)
Italy			0.16			-0.09	2.43	0.77
			(4.43)			(-9.87)	(11.160)	(4.78)
Latvia			0.19	-0.13		-0.14	2.45	0.76
			(3.45)	(-4.98)		(-2.56)	(11.67)	(4.45)
Lithuania	-0.20	-0.46	0.28	0.19	0.14	-0.26	2.45	0.77
	(7.78)	(-20.22)	(9.17)	(6.88)	(9.43)	(-2.98)	(11.56)	(4.89)
Luxembourg			0.34			-0.18	2.41	0.73
			(2.45)			(-2.92)	(10.98)	(4.09)
Malta			0.32			0.09	2.46	0.77
			(3.76)			(3.76)	(11.88)	(4.56)
Netherlands			0.32			-0.24	2.43	0.76
			(3.55)			(-4.92)	(11.36)	(4.44)
Portugal	-0.08	-0.52	0.03	0.23		-0.11	2.40	0.75
	(-2.67)	(-3.76)	(2.09)	(2.65)		(-2.98)	(10.88)	(4.27)
Romania	0.11	-0.32	0.53	-0.08	0.27	0.09	2.44	0.77
	(2.77)	(-9.04)	(14.34)	(-2.65)	(7.88)	(6.87)	(11.54)	(4.55)
Slovenia	-1.00	-0.57	0.9	0.90	0.58	0.08	2.43	0.77
	(-21.34)	(-17.47)	(8.87)	(17.14)	(14.87)	(12.01)	(11.54)	(4.45)
Spain			0.32			-0.04	2.44	0.78
			(3.19)			(-4.68)	(12.09)	(4.89)
Sweden	0.35		0.09	-0.16	-0.22	-0.36	2.43	0.75
	(2.54)		(2.32)	(-2.65)	(-3.12)	(-4.54)	(11.22)	(4.12)
UK	0.48		0.44	-0.42		-0.29	2.41	0.78
	(4.09)		(4.76)	(-3.76)		(-4.15)	(11.01)	(4.89)

Notes: The estimations are obtained from the Pooled Mean Group approach with long-run parameters estimated with CCE techniques. The coefficients of the variables $\overline{R}_t$ *and* $\overline{G}_t$ of equation (8c) have not been reported in the table. t-statistics are in brackets.