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Panel cointegration analysis for the European Union Member countries

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Abstract

In this study, we analyse the sustainability of fiscal policy of EU member countries within the panel cointegration and error-correction frameworks. Unlike the previous empirical papers in this area, we apply the test for panel cointegration between the primary budget deficit and the public debt defined in GDP ratios. Based on the cointegration test results, we conclude that the fiscal policy is consistent with the intertemporal budget constraint, i.e., it is sustainable in the panel of fifteen EU member countries over the period from 1970 to 2004. Hence, we show that the fiscal balance exhibits a significant structural change in the year 1992, when we apply the *Banerjee and Carrion-i-Silvestre (2006)* test for a structural break in the panel cointegration relationship. In a next step, we search for the politico-economic factors which explain the variation in the sustainable fiscal balance among the European countries. We evidence that the European fiscal rules have a significant positive effect on the improvement of the fiscal position of the governments of the EU member countries.

Keywords: Sustainability, Budget Deficit; Panel Cointegration, Structural Breaks, Panel error-correction method

JEL Classification: H62, H63, C32

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1 Introduction

In recent years, growing attention is paid to fiscal sustainability in Europe. Both, the debt and the deficit criteria, which are defined in the Maastricht Treaty, and the Stability and Growth Pact are relevant to ensure the sustainability and stabilization of the public finance in the European Union (EU) member countries. The Treaty sets the maximum limits of the budget deficit-GDP ratio for an entry into the monetary union at three percent and allows for the long-run debt convergence about 60 percent of GDP (by assuming the trend growth of three percent and the trend inflation of two percent). The Stability and Growth Pact, which introduces the financial fine for the violation of the deficit criteria, requires the balanced fiscal position or the budgetary surplus in the medium-run.

Following the discussion about the potential effects of the fiscal policy institutions in the EU, a number of empirical studies examines the sustainability of the budget deficit and public debt, and the impact of the fiscal rules on the improvement of the fiscal position of the governments in the EU member countries. These studies differ with respect to the methodological approaches used to examine the sustainability hypothesis, and the results reported. *Caporale (1995)* studies the sustainability of the fiscal policy in ten European union countries, and reports the sustainable fiscal balance for Belgium, France, Ireland, the Netherlands, Spain, and the UK, while evidences the violation of the intertemporal budget constraint for Denmark, Germany, Greece, and Italy. *Vanhorebeek et al. (1995)* apply the test for stationarity of the primary budget deficit- and the debt-GDP ratios to the sample of eight European countries over the period from 1970 to 1994 in order to study the sustainability. They evidence the stationary primary budget deficit ratio for France, Denmark, and Germany, while fail to verify this hypothesis for Ireland, Italy, and the Netherlands. Hence, they demonstrate the sustainable public debt-GDP ratio only for the UK, and find the trend-stationary ratio for Belgium and Denmark.

An equivalent framework is used by *Papadopoulus et al. (1999)*. They apply the test for cointegration between the revenue and expenditure with the vector (1, -1) in order to examine the sustainability hypothesis for the sample of five European Union countries over the period from 1961 to 1995. Given the large budget deficit and growing public debt-GDP ratio in these countries over the time period under study, they find that the revenue and expenditure are cointegrated with the coefficient significantly lower than one for Greece, Spain, and Portugal. This observation implies that the intertemporal budget constraint is fulfilled since the revenue and expenditure are in their long-run equilibrium relationship, but the governments have the problem to manage their exploding public debt. Furthermore, they demonstrate the violation of the intertemporal budget constraint for Italy and Belgium. *Bravo and Silvestre (2002)* apply this test for cointegration to the sample of eleven European Union countries over the period from 1960 to 2000. They verify the sustainability hypothesis for Austria, France, Germany, the Netherlands, and the UK, and report its violation for Belgium, Denmark, Finland, Ireland, Italy, and Portugal. *Payne (1997)* uses the same methodology to study the fiscal sustainability in the sample of the G-7 countries, and finds support only for Germany and the UK. In a more

recent study, *Afonso (2005)* explores the same framework to study the sustainability in the sample of fifteen EU member countries. He demonstrates that the revenue and expenditure are cointegrated only for Austria, Finland, Germany, and the Netherlands, but shows that the cointegration coefficient is significantly lower than one. Furthermore, for Belgium, Denmark, Portugal, and the UK, he finds the significant structural break in the cointegration relationship between the revenue and expenditure which fundamentally changes the structure of the fiscal balance.

Unlike the previous studies, in this paper we examine the sustainability hypothesis in the panel of fifteen EU member countries over the period from 1970 to 2004. To avoid the problem of the former studies, which apply the conventional time-series tests to the relatively short time-series, we use the panel cointegration framework. The empirical strategy of the study is as follows. In a first step, we employ the test for the panel-cointegration between the primary budget deficit and public debt given that both series are non-stationary and are of the same order of integration. Hence, as the criteria defined in the Maastricht Treaty and the Stability and Growth Pact are regarded as sufficient conditions to ensure the fiscal sustainability, in a next step, we examine whether these institutions have significant impact on the improvement of fiscal position of the governments in the EU area within the panel error-correction approach.

The paper is organised as follows. *Section 2* presents the theoretical framework and discusses the existing empirical literature. *Section 3* provides a discussion of the time series. Furthermore, it presents the panel unit root tests results and moves on to the panel-cointegration test results. *Section 4* continues the analysis with the model of sustainable budget deficit and presents the empirical results for the panel of 15 European countries. *Section 5* contains concluding remarks.

2 Review of the Empirical Literature and Theoretical Framework

Within the panel framework, where $t = 1, ..., T$ are the time series observations on $i = 1, ..., N$ countries, the theoretical approach of fiscal sustainability uses the budget constraint of the government defined by

$$(1) \qquad G_{i,t} + (1 + i_{i,t}) B_{i,t-1} = R_{i,t} + B_{i,t},$$

where $B_{i,t}$ represents the stock of public debt, while $i_{i,t}$ denotes the ex-post interest rate for public debt; $R_{i,t}$ is the government revenue including the revenue from seignorage, and $G_{i,t}$ is the expenditure excluding interest payments, respectively. Defining the government budget constraint in terms of GDP-ratios, we can rewrite equation (1) as

$$(2) \qquad \frac{G_{i,t}}{Y_{i,t}} + \frac{(1 + i_{i,t})}{(1 + \sigma_{i,t})} \frac{B_{i,t-1}}{Y_{i,t-1}} = \frac{R_{i,t}}{Y_{i,t}} + \frac{B_{i,t}}{Y_{i,t}},$$

where $Y_{i,t}$ is the nominal GDP, and $\sigma_{i,t}$ denotes the nominal GDP-growth rate. Defining the lower-case letters as ratios of the corresponding upper-case variables to nominal GDP, we simplify the equation (2) for the analysis as

(3) $$g_{i,t} + (1 + i*_{i,t}) b_{i,t-1} = r_{i,t} + b_{i,t},$$

where $i*_{i,t}$ is the interest rate adjusted for the economic growth rate, given by $i*_{i,t} = ((1 + i_{i,t}) / (1 + \sigma_{i,t}) - 1)$. By suggesting that equation (3) holds for each period, and assuming the constant interest rate, we can rewrite the intertemporal budget constraint for the period from $\tau = t$ to $\tau = T$ when performing the forward substitution as

(4) $$b_{i,t-1} = \sum_{i=1}^{N} \sum_{\tau=t+1}^{\infty} \left[\frac{1}{(1 + i*_i)^{\tau-t}} s_{i,\tau-1} \right] + \lim_{\tau \to \infty} \left[\frac{1}{(1 + i*_i)^{\tau-t}} b_{i,\tau-1} \right],$$

where $s_{i,t}$ denotes the primary budget surplus defined by $s_{i,t} = r_{i,t} - g_{i,t}$. The literature derives the condition of sustainable fiscal policy depending on the trajectory of development of the second term of condition (4). If suggesting that the transversality condition holds, i.e.,

(5a) $$\lim_{\tau \to \infty} \left[\frac{1}{(1 + i*_i)^{\tau-t}} b_{i,\tau-1} \right] = 0,$$

the intertemporal budget constraint of the government is given by

(5b) $$b_{i,t-1} = \sum_{i=1}^{N} \sum_{\tau=t+1}^{\infty} \left[\frac{1}{(1 + i*_i)^{\tau-t}} s_{i,\tau-1} \right].$$

Condition (5a), which is known as the 'no Ponzi game rule' requires that the public debt must not grow at a rate greater than the interest rate. If this condition is fulfilled, then the intertemporal budget constraint implies the equality between the stock of the market value of public debt and the sum of discounted future budget surpluses. If this condition is valid, the theory predicts the fiscal policy of the government to be sustainable.

Starting with condition (5) as a testable relation, the empirical literature proposes several frameworks to examine the sustainability hypothesis. One direction of the studies suggests test for the stationarity of the primary budget surplus in order to check whether the transversality condition holds. Given the relation (5) as a testable condition, *Hamilton and Flavin (1986)* make the assumption about the constant real interest rate, and suggesting the constant violation of the intertemporal budget constraint (i.e., $A_{i,0} > 0$), they derive the testable hypothesis by

(6) $$b_{i,t-1} = \sum_{i=1}^{N} \sum_{\tau=t+1}^{\infty} \left[\frac{1}{(1 + i*_i)^{\tau-t}} s_{i,\tau-1} \right] + \left[\frac{1}{(1 + i*_i)^{-t}} A_{i,0} \right].$$

They argue that the null hypothesis that the intertemporal budget constraint is fulfilled is valid if and only if $A_{i,0} = 0$. They define the stationarity of the primary budget deficit as a *sufficient*

condition for fiscal policy to be sustainable. However*, Wilcox (1989)* derives the condition for sustainable fiscal policy which suggests that the discounted value of public debt must go to zero in the infinite future when allowing for the time-varying interest rate.

An equivalent to the *Hamilton and Flavin's (1986)* framework of testing for stationarity of the primary budget deficit implies examination of the cointegration relationship between the revenue and expenditure with cointegrating vector (1, -1). *Hakkio and Rush (1991),* and *Quintos (1995)* in order to derive the testable condition propose to rewrite the relation (5) with the total government expenditure $g_{i,t}^r = g_{i,t} + i*_{i,t} b_{i,t-1}$ as

$$(7) \qquad g_{i,t-1}^r = r_{i,t-1} + \sum_{i=1}^{N} \sum_{\tau=t+1}^{\infty} \left[\frac{1}{(1+i*_i)^{\tau-t}} (\Delta r_{i,\tau-1} - \Delta g_{i,\tau-1}) \right] + \lim_{\tau \to \infty} \left[\frac{1}{(1+i*_i)^{\tau-t}} \Delta b_{i,\tau-1} \right],$$

where $\Delta r_{i,\tau}$ and $\Delta g_{i,\tau}$ are assumed to be stationary. Following condition (7), and assuming that the transversality condition holds, *Quintos (1995)* defines the cointegration between the revenue $r_{i,t}$ and expenditure $g_{i,t}^r$ with cointegrating coefficient close to one, given that both series are non-stationary and of the same order of integration, as the *necessary and sufficient condition* for intertemporal budget constraint to be valid, while the cointegration with $0 < \hat{\beta}_i < 1$ is only a *sufficient condition*.

Finally, an alternative method to examine whether the data are consistent with the intertemporal budget constraint requires studying the cointegration relationship between the public debt and the primary budget deficit given if both series are non-stationary processes. *MacDonald (1992)* proposes to subtract $i_i^{-1} s_{i,t-1}$ from both sides of the relation (5b), deriving the following testable hypothesis by

$$(8) \qquad b_{i,t-1} - \frac{1}{i_i*} s_{i,t-1} = \sum_{i=1}^{N} \sum_{\tau=t+1}^{\infty} \left[\frac{1}{(1+i_i*)^{\tau-t}} (s_{i,\tau-1} - s_{i,\tau-2}) \right].$$

Here, he defines that the term $s_{i,\tau-1} - s_{i,\tau-2}$ results from the suggestion of i_i^{-1} as the sum of the weights on $\Delta s_{i,\tau-1}$. This condition (8) implies that the test, which is based on the examination of stationarity of $\Delta s_{i,\tau-1}$ is equivalent to the test for stationarity of the linear combination ($i*_i b_{i,t-1} - s_{i,t-1}$). Starting with the relation (8), and using the *Engle-Granger (1987)* definition, given that the model is fully specified, the cointegration implies the existence of one parameter $i*_i$ which guarantees that the linear combination

$$(9) \qquad s_{i,t} - i*_i b_{i,t} = \varepsilon_{i,t}$$

is stationary in levels, i.e., I(0)-process; it suggests that the primary budget deficit and public debt are cointegrated. The equilibrium relationships are given then by

$$(10) \qquad s_{i,t} = i*_i b_{i,t},$$

where the vector $\beta'_i = (1, -i^*_i)$ is the cointegrating vector.

Equivalently, following the *Granger representation theorem* (*Engle-Granger, 1987, p.255f.*), the cointegration between the budget deficit and public debt can be expressed by using the error-correction representation, which is given by

$$(11) \qquad \Delta s_{i,t} = \alpha_i + \lambda_i(s_{i,t-1} - i^*_i b_{i,t-1}) + \delta_{i,s}\Delta s_{i,t-1} + \delta_{i,b}\Delta b_{i,t-1} + u_{i,t},$$

where the term λ_i is the adjustment coefficient, and $u_{i,t}$ is white noise, which may be contemporaneously correlated. This model describes the variations in budget deficit and public debt around their long-run trends, and the error-correction $(s_{i,t-1} - i^*_i b_{i,t-1})$, which is the equilibrium error in the cointegration model. Statistically significant term λ_i supports the hypothesis that the primary budget surplus and the public debt are cointegrated, and shows that the error-correction model is a valid representation of the data. In this context, the error-correction model shows that although the development of the primary budget deficit and public debt may diverge in the short run, the fiscal variables will adjust when deviation between them differ from the equilibrium development, so that in the long run the budget deficit and public debt will move together. In the projection of the future fiscal policy variables on the information set in the period t, it is important to assume that the government budget constraint restricts the joint movements of the budget deficit and public debt.

Applying these results, we can formulate the following testable hypothesis.

Hypothesis 1

The fiscal policy satisfies the intertemporal budget constraint (i.e., sustainable), if the primary budget deficit and the public debt are cointegrated.

Hence, the relation (11) implies that the variation in sustainable fiscal balance among the European Union Member countries in the panel can be explained by some institutional factors. As we want to determine the factors which have an influence on the improvement in the fiscal balance, we examine additionally the following testable hypotheses.

Hypothesis 2

This hypothesis argues that the sustainability of the government finance in the EU area closely relates to the commitment of the *Maastricht Treaty* (ratified in Maastricht in 1992) and the *Stability and Growth Pact (SGP)* (ratified on June 1997 in Amsterdam). We expect the restrictive effect of the European fiscal rules on the increase in budget deficit-GDP ratio.

Hypothesis 3

Moreover, the budgetary performance and the capacity of the governments to meet the criteria of sustainable fiscal policy can be affected by the process of *decentralization* with increased division of the budgetary responsibilities between the different levels of the government. The theory predicts the negative relationship between the sustainable fiscal balance and the degree of fiscal decentralization of the government.

Hypothesis 4

The next hypothesis studies the impact of the *political cycles* on the sustainability of the fiscal balance. Both, the theoretical and empirical literatures suggest the significant effect of the political cycles on the fiscal policy outcome; the governments are willing to provide more expansionary fiscal policy in the pre-election time period (*Nordhaus, 1975, Frey and Schneider, 1978 a and b, Alesina, Roubini and Cohen, 1997*). This line of the literature predicts that in a more politically uncertain environment, the government shows its willingness to increase the expenditure before the parliamentary elections and to leave the higher public debt for the next government

Hypothesis 5

Another direction of the literature studies the effect of the *electoral laws* on fiscal policy outcome (*Persson and Tabellini, 1999*). Using this approach, *Persson and Tabellini (1999)* show that countries with majoritarian election rules tend to have larger redistribution programmes and the size of public sector. This literature predicts that the variations in fiscal policy outcome can be explained by the differences in the electoral systems (majoritarian vs. proportional).

3 Empirical Methodology, Data and Results

3.1 Empirical Methodology

Thus, in this study, we examine this sustainability of the fiscal balance in the panel of nine EU member countries over the period from 1970 to 2005. The empirical strategy of the study is as follows. In the first step, we employ the test for panel cointegration between the market value of the public debt and the primary budget deficit defined as GDP ratios in order to test the *Hypothesis 1*. Provided that the deficit- and debt-GDP ratios are cointegrated, we conclude that the fiscal policy in the EU area is consistent with the intertemporal budget constraint, i.e., it is sustainable. Furthermore, we suggest that the cointegration relationship implied by the intertemporal budget constraint may not be stable over the whole time period considered; it

may exhibit significant structural breaks caused by the changes in the national and international fiscal policy rules. To study these shifts, we apply the *Banerjee and Carrion-i-Silvestre (2006)* test for structural break in the panel cointegration relationship. And finally, we use an alternative, error-correction representation in order to re-examine the hypothesis whether the budget deficit and the public debt are cointegrated. Additionally, we search for the politico-economic factors which explain the variation in the sustainable fiscal balance among the European countries within the error-correction approach when examining the *Hypotheses (2)-(5)*.

3.2 Data

We examine the sustainability of the public debt and the budget deficit in the panel of fifteen European Union countries over the period from 1970 to 2004. The data for all countries are taken from the *European Commission AMECO* (Annual Macroeconomic Data) database, updated in December 2005. Countries included in the sample are *Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and United Kingdom*. The series include general government public debt, price deflator of final private consumption expenditures, and the gross domestic product (GDP). For the analysis, we employ the fiscal series defined as GDP ratios. The ratios are obtained by dividing their nominal values by the GDP. The sources of the data are given in the *Appendix*, *Table A 2.2*.

3.3 Results

In the first step, we examine the stationarity properties of the individual time series, the primary budget deficit and the public debt, both defined in GDP ratios for each country when we apply the Augmented Dickey-Fuller (ADF), the Phillips-Perron (PP), and DF-GLS test in order to provide the comparatibility and the benchmark for the results reporter later. The number of lags is chosen by using the Hannan-Quinn information criterion. We perform the unit root tests for the variables in levels and first differences. The results for each of the fifteen European countries are depicted in *Table 1*.

[Insert Table 1 about here]

Following the literature, which defines the difference-stationarity of the public debt as the *sufficient condition* for the intertemporal budget constraint to be valid (*Trehan and Walsh, 1991*), we apply the test for unit root to the public debt-GDP ratio for the individual countries. The test results evidence that this ratio is difference-stationary (i.e., I(1)-series) for Austria,

Finland, France, Germany, Greece, Ireland, Luxembourg, the Netherlands, Portugal, Sweden, and the UK. Exceptions are the debt series for Belgium, Denmark, Luxembourg, and the UK.

In a next step, we check an alternative sustainability condition which implies examination of whether the primary budget deficit is stationary in levels (i.e., I(0)-series) when we apply the same set of the tests to the deficit-GDP ratio for the individual countries. The ADF- and PP-tests imply the stationarity of the primary budget deficit-GDP ratio for Germany, Luxembourg, Sweden, and the UK.

The literature suggests the low power of the conventional unit root tests in the case of short time span (T=34), and of the high persistence in the model, i.e., if the dominant root is close to unity (*Ng and Perron, 1999*). Therefore, we carry out the panel unit root tests which combine the time series and the cross-sectional information for the panel data (see *Maddala and Wu, 1999*). The first test applied is the *Levin and Lin (LL)-test (1993)* which is an extension of the standard Dickey-Fuller test to the panel framework. It takes the heteroscedasticity and autocorrelation in the panel into consideration. The limitation of the LL-test is the assumption of homogeneity and independent error terms across cross-sectional units. As the LL-test uses a very restrictive hypothesis, and is of little practical interest, we conduct additionally the *Im, Pesaran and Shin (IPS) (1997)* test which is based on the assumption of the heterogeneous parameters. While the IPS test as a parametric, asymptotic test examines the significance of the test results from N independent tests of the null hypothesis, an alternative approach is used by the non-parametric *Fisher (1932)* test which is an exact one; it combines the p-values from the individual unit root tests (*Maddala and Wu, 1999*). The asymptotic results for the later two tests depend on different conditions: the results of the IPS-test depend on the number of the cross-section units, while those of the Fisher test depend on the number of the time observations in the panel.

The LL-, IPS-, and the Fisher-tests results are presented in *Table 2*. These results imply that the public debt-GDP ratio is stationary in the first differences (i.e., I(1)-series). Hence, it shows that the primary budget deficit-GDP ratio can be defined as I(1)-series by using the LL-test.

[Insert Table 2 about here]

Consequently, we treat both series, the public debt- and the budget deficit-GDP ratios as I(1)-series and study the cointegration between these variables in order to examine the consistency of the fiscal policy with the intertemporal budget constraint in the panel of fifteen European countries in a next step.

3.3.1 Panel cointegration analysis

Next, we examine the question of whether the fiscal policy fulfils the intertemporal budget constraint by conducting the test for cointegration between the primary deficit- and public debt-GDP ratios in a panel of fifteen EU countries. The literature defines several approaches to perform the panel cointegration test; see *Banerjee (1999)* for the overview of the panel-cointegration tests. One approach, which is analogous to the bivariate *Engle-Granger (1987)* test, examines the null hypothesis of no cointegration by using the residuals from the panel cointegration model (*Pedroni, 1999*). The *Pedroni (1999)* framework works with the residuals from the following cointegration regression

(12) $$d_{i,t} = \alpha_i + \beta_i \, \text{Trend} + \delta_i b_{i,t} + \varepsilon_{i,t},$$

where $d_{i,t}$ is the primary budget deficit-GDP ratio, $\delta_i = (\delta_{1i}, \delta_{2i}, ..., \delta_{Mi})'$, T is the number of observations over time ($t = 1,2,...,T$), N denotes the number of countries in the panel ($i = 1,...,N$), and M is the number of regressors ($m = 1,...,M$). Here, the term 'Trend' denotes the time trend, and $\varepsilon_{i,t}$ is the error term.

This model allows for the heterogeneous slope coefficients, fixed effects and the individual specific deterministic trends. In order to perform this panel cointegration test, *Pedroni (1997)* develops seven different test-statistics. Here, we use two of these statistics, the parametric t-statistic which is seen as an analogous to the Levin and Lin panel unit root statistic applied to the estimated residuals of cointegrating regression (12), and the parametric group t-statistics which is considered as an analogue to the IPS group mean unit root statistic when applied to residuals of regression (12). For both tests, the sufficiently large negative values of calculated test-statistics mean the rejection of the null hypothesis of no cointegration.

In a first step, we proceed to test for cointegration between the deficit- and debt-GDP ratios by applying the *Engle-Granger (1987)* test to the individual country data. This method is based on the ordinary-least squares (OLS) residuals $\hat{\varepsilon}_t$ from the cointegrating regression (12) for each individual country in the sample and examines the null hypothesis of no cointegration. The results of the test are reported in *Table 3*.

The table depicts the ADF- and DW-test values for the model (12) and the estimated cointegrating coefficients by using the OLS. The results allow rejecting the null hypothesis of no cointegration for a large group of countries. For France, Germany, Luxembourg, Portugal, Sweden, and the UK, there is strong evidence in favour of cointegration between the primary deficit- and debt-GDP ratios that implies the consistency of the fiscal policy with the intertemporal budget constraint.

[Insert Table 3 about here]

In a next step, we conduct the *Pedroni (1997, 1999)* panel cointegration test in order to examine the sustainability hypothesis. The results are given in *Table 4* for the cointegrating model (12) when we estimate additionally the model with the alternative dependent variable. The model is estimated by including the country-fixed effects. Here, we depict two test-statistics proposed by *Pedroni (1997)*, the panel and the group t-statistics.

The test results indicate that the null hypothesis of no panel cointegration can be rejected by the group t-statistic for the model when the deficit-GDP ratio is a dependent variable. If we estimate the model with the debt-GDP ratio as a dependent variable, we fail to reject the null hypothesis.

[Insert Table 4 about here]

Overall, the results of the panel cointegration test verify the hypothesis that the deficit- and debt-GDP ratios are cointegrated in the panel of fifteen EU member countries over the period from 1970 to 2004.

3.3.2 Banerjee and Carrion-i-Silvestre (2006) test for structural breaks in cointegration relations

Hence, we additionally examine the effects of possible structural breaks on the stability of cointegration relation by applying the *Banerjee and Carrion-i-Silvestre (2006)* methodology. This approach is an extension of the *Gregory-Hansen (1996)* test to the panel framework developed by *Pedroni (1997, 1999)*.

Banerjee and Carrion-i-Silvestre (2006) analyse seven different cases when the structural shifts have substantial effect on stability of the results of the panel cointegration method of *Pedroni (1999);* here, we apply only three of these cases. The first one is related to the model which incorporates the structural change in the level at break point T_{bi}; the model assumes a stable cointegrating vector. This case can be described by model A

(13) $$d_{i,t} = \alpha_i + \beta_i \text{Trend} + \theta_i DU_{i,t} + \delta_i b_{i,t} + \varepsilon_{i,t},$$

where $DU_{i,t}$ is a dummy variable which is defined by

$$DU_{i,t} = \begin{cases} 0 & t \leq T_{bi} \\ 1 & t > T_{bi} \end{cases},$$

for the given T_{bi} as the break point, and Trend as the time trend. The model, which must be estimated to calculate the *Pedroni (1997)* panel data cointegration test-statistic, includes a constant term (the individual effect) as a deterministic component.

The model B assumes the time trend with the changes in both, the level and the trend function, but which captures the assumption of stable cointegrating vector. This model is given by

(14) $\qquad d_{i,t} = \alpha_i + \beta_i \text{Trend} + \theta_i DU_{i,t} + \gamma_i DT_{i,t} + \delta_i b_{i,t} + \varepsilon_{i,t}$,

where, $DT_{i,t}$ is a dummy variable defined by

$$DT_{i,t} = \begin{cases} 0 & t \le T_{bi} \\ (t - T_{bi}) & t > T_{bi} \end{cases}.$$

The panel cointegration test-statistic is computed by using the time trend and the deterministic component.

And finally, the model C allows for the time trend with the changes in both, the level and the slope, and accounts for the shift in the cointegrating vector

(15) $\qquad d_{i,t} = \alpha_i + \beta_i \text{Trend} + \theta_i DU_{i,t} + \gamma_i DT_{i,t} + \delta_{i,t} b_{i,t} + \varepsilon_{i,t}$,

where, the cointegrating vector $\delta_{i,t}$ is specified as a function of time by

$$\delta_{i,t} = \begin{cases} \delta_{i,1} & t \le T_{bi} \\ \delta_{i,2} & t > T_{bi} \end{cases}.$$

Using each of the defined specifications of the model, *Banerjee and Carrion-i-Silvestre (2006)* propose to examine null hypothesis of no cointegration against the alternative hypothesis of cointegration with structural break common for all cross-sectional units in the panel data framework as proposed by *Pedroni (1999, 2004). Banerjee and Carrion-i-Silvestre (2006)* show that in the first case, the shift in levels matters only when the magnitude of shift is large and the break occurs at the end of the period. It follows that for the small shifts in level, the incorrect specification error of deterministic component does not influence the power of Pedroni test-statistics. In the second case, the empirical power of the test diminishes substantially if the break occurs either in the middle or at the end of the considered period. And finally, in the third case, the change in the cointegrating vector can have a moderate or a large diminishing effect on the power of the test-statistic if the break point is located in the middle or the end of the period.

The results of the IPS(τ)-statistics of the residuals from each of three estimated cointegrating models (13)-(15) by treating each year over the period [(0.15T),(0.85T)] as a possible break point are depicted in *Figure 1*, and the results of the LL(τ)-statistics are reported in *Figure 2*.

The results of both tests, the IPS- and the LL-test indicate the significant structural break in the year 1992. These findings confirm with the assumption of the effect of institutional changes in the EU on the changes in primary budget deficit-GDP ratio.
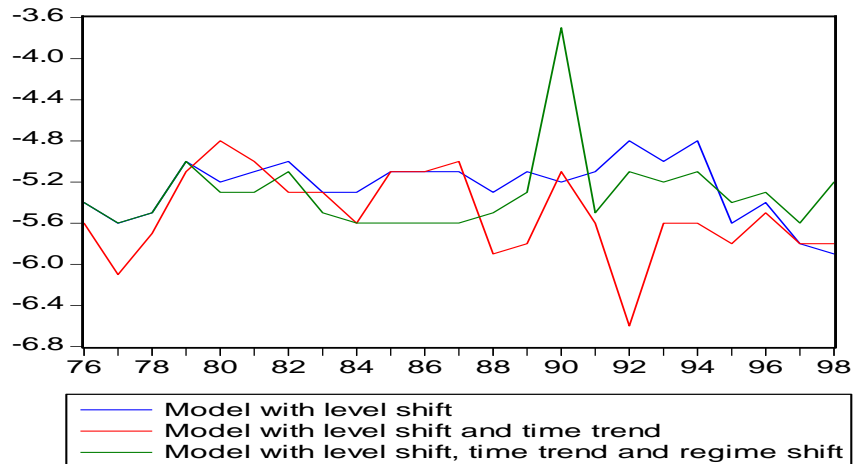
Figure 1: Test-statistics of the IPS(τ)-test for cointegration between primary deficit- and public debt-GDP ratios for the period [(0.15T),(0.85T)]
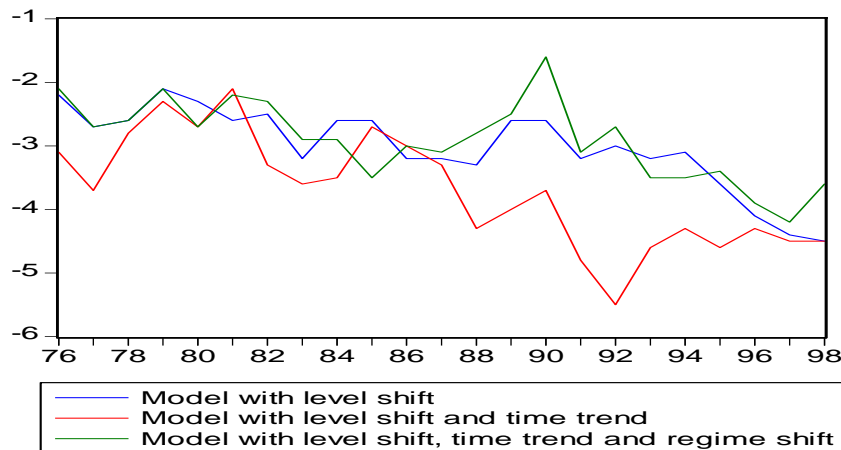

Figure 2: Test-statistics of the LL(τ)-test for cointegration between primary deficit- and public debt-GDP ratios for the period [(0.15T),(0.85T)]

4 The determinants of sustainable budget deficit in the panel of European countries

So far we found, that the sustainability hypothesis is verified in the panel of fifteen EU member countries. In the next section, we search for the factors which explain the variations in the fiscal imbalance among the European countries within the panel error-correction approach. We use the dynamic error-correction method (ECM) which is verified by the existence of the cointegration relation between the budget deficit and public debt defined in GDP ratios (*Engle and Granger, 1987*). Here, we adopt the panel error-correction method as proposed by *Canning and Pedroni (1999),* which is a two-step method. In a first step, we estimate the cointegrating relation between the budget deficit and public debt by using the ordinary least-square (OLS) method for each individual country. In a second step, we use these estimated cointegrating relationships to calculate the non-equilibrium

term $\hat{\varepsilon}_{i,t} = d_{i,t} - \hat{\alpha}_i - \hat{\beta}_i \text{Trend} - \hat{\delta}_i b_{i,t}$. Finally, we estimate the error-correction model (ECM). Within this approach, the error-correction term represents the deviation of the budget deficit and public debt from their long-run equilibrium relationship. The advantage of the error-correction method is that since all variables in the model are stationary, the super-consistency of the estimator of cointegrating relation allows applying the standard tests on significance of the coefficients in the regression (*Toda and Phillips, 1993*). The trade-off of this approach is that we can examine only the existence and the sign of the long-run effect, but we can not interpret its magnitude (*Canning and Pedroni, 1999*).

The error-correction regression to be estimated is defined as

$$(16) \qquad \Delta d_{i,t} = \alpha_i + \beta_i \text{Trend} + \sum_{j=1}^{T} \delta_{1i,j} \Delta b_{i,t-j} + \sum_{j=1}^{T} \delta_{2i,j} \Delta d_{i,t-j} + \lambda_i \hat{\varepsilon}_{i,t-1} + \varphi_i CV_{i,t} + u_{i,t},$$

where both series, the primary budget deficit- GDP ratio ($d_{i,t}$) and the stock of the public debt GDP ratio ($b_{i,t}$) are I(1)-series. The term $\hat{\varepsilon}_{i,t}$ is the error-correction term, and Δ denotes the difference operator; the variable $CV_{i,t}$ represents the set of the control variables, and $u_{i,t}$ is the error term. Subscripts i = 1…15 identify the countries, and t = 1970…2004 are the years. In order to control the outliers, we introduce the dummy variables in the model (16) (for Belgium for the year 1981, Finland for the 1991, Germany for the 1975, Greece for the 1981, Italy for the 1975, Luxembourg for the 1982 and the 1983, and Sweden for the years 1984 and the 1991). Econometric analysis is performed by using the pooled cross-sectional time series model and the ordinary least squares (OLS) estimator with panel corrected standard errors. The number of lags is chosen so that the estimated residuals do not exhibit significant autocorrelation. This model allows us to estimate both, the short-run and the long-run relation between the deficit- and the debt-GDP ratios. The short-run effect of public debt- on the budget deficit-GDP ratio is given by the lagged differences of the debt-GDP ratio in regression (13). To check the significance of this effect, we conduct the t-test for the coefficient of this term $\hat{\delta}_{1i,j}$ in the regression (16). Hence, we examine the significance of the error-correction term. If the coefficient $\hat{\lambda}_i$ of the lagged error-correction term is negative and significantly different from zero, it would imply the long-run effect of the public debt on the budget deficit defined as GDP ratios.

Hence, in order to examine the *Hypothesis 2* we introduce two dummy variables in the regression (16). The first dummy variable takes the value one in the year when the Maastricht Treaty was approved, and zero otherwise. The second dummy variable, which accounts for the effects of the Stability and Growth Pact, takes the value one in the year 1997 in countries of the Euro area, and zero otherwise. Moreover, to test the *Hypothesis 3* we follow the previous literature, and introduce the dummy variable which takes the value one for the countries with the federal structure of government, and zero otherwise. Testing the *Hypothesis 4* requires the introduction of the dummy variable which takes the value one in the year of the

parliamentary elections in each country in the panel, and zero otherwise. Finally, examination of the *Hypothesis 5* suggests inclusion of the dummy variable which accounts for the majoritarian electoral systems. The description of the variables is given in the *Appendix*.

The empirical results are given in *Table 5*. The estimated model (16) performs relatively well; it captures the short- and the long-run dynamics in the variables in a correct way. The Jarque-Bera test statistic suggests the normality of distribution of the residuals. The Durbin-Watson test suggests the absence of autocorrelation in residuals.

In a first step, we examine the short-run effect of the public debt on the budget deficit (both measured in GDP-ratios) by conducting the standard χ^2- Wald test. Under the null hypothesis of no effect, the test statistic follows the chi-squared distribution with the degrees of freedom equal to the number of restrictions imposed.

[Insert Table 5 about here]

Large value of this statistic allows rejecting the null hypothesis. The results evidence the significant positive short-run effect of the public debt on the deficit-GDP ratio. This evidence supports the Ricardian equivalence theorem which, in order to fulfil the intertemporal budget constraint, requires the response of the government to an increase in public debt by decreasing the primary budget deficit

In a second step, we examine the issue whether the public debt has a long-run effect on the budget deficit by applying the χ^2- Wald-test as well. The test results reject the null hypothesis of no significant effect at all conventional levels of significance; the coefficient on the error-correction term in deficit equation is significantly negative supporting the theoretical prediction.

Next, we test the hypothesis on the impact of the European fiscal policy rules, the Maastricht Treaty, and the Stability and Growth Pact on sustainability of the budget deficit in the panel of the European Union member countries by including two dummy variables. *Table 5* demonstrates that both dummy variables have significant negative effect on change in budget deficit-GDP ratio. This evidence suggests that the introduction of the EU deficit criteria is significantly related to the decrease of the primary budget imbalance over time.

Next, we examine the hypothesis of whether the parliamentary elections substantially influence the fiscal outcome of the governments in the European countries. The test results are depicted in *Table 5* as well. The coefficient on dummy variable which takes the value one in the year of the parliamentary elections, and zero otherwise is positive and statistically significant; it implies an increase in fiscal imbalance in the election years. These findings suggest that the governments, facing the elections provide more expansionary fiscal policy when increase the public expenditures and leave the larger public debt for the future governments. These results are compatible with the conclusions of the previous empirical

literature (*Tujula and Wolswijk, 2004, Afonso, 2005*). However, we find that neither the majoritarian electoral system nor the federal structure of government can explain the deterioration of the fiscal balance in the panel of fifteen EU member countries; both dummy variables are statistically insignificant by using this specification of the model.

5 Concluding remarks

The sustainability of the fiscal policy of the EU countries is one of the most widely investigated issues in the last years. The fiscal framework enforcing the sustainability and stabilization of the public finance in the EU countries was implemented in the Maastricht Treaty and the Stability and Growth Pact. The objective of this study is to examine the sustainability of the fiscal policy in a panel fifteen European Union member countries, and to study whether the mentioned European institutions significantly contribute to the improvement of their fiscal balances.

The study represents the first attempt to address the sustainability hypothesis within the panel framework in the European countries when examining the cointegration between the budget deficit and public debt. The used panel cointegration methodology has several advantages in comparison to the univariate analysis applied in the empirical literature (*Afonso, 2005*). Firstly, it avoids power distortions of the conventional unit root and cointegration tests as a result of the small size of the sample used. Second, as the budget deficit and the public debt are cointegrated, we additionally use the error-correction representation in order to estimate both, the short- and the long-run response of the budget deficit to an increase in the public debt.

Two main points emerge from the analysis performed. Firstly, we find the evidence supporting sustainability of the fiscal balance in the EU area (*Hypothesis 1*); we show that the budget deficit- and the public debt-GDP ratios are cointegrated over the considered period. Exploring the analysis for the single member countries, we find that the deficit- and the debt-GDP ratios are cointegrated for France, Germany, Luxembourg, Portugal, Sweden, and the UK. These results are compatible with the findings of the alternative empirical studies (*Afonso, 2005*). For the remaining countries in the sample, we cannot reject the null hypothesis of no cointegration.

Secondly, we find the significant impact of the European institutional arrangements on the improvement of the fiscal policy outcome in the EU member countries (*Hypothesis 2*). Both institutions examined, the Maastricht Treaty and the SGP have a significant negative effect on the change in the deficit-GDP ratio. This conclusion is based on two tests conducted: we find significant structural break in the cointegration relationship between the budget deficit- and public debt GDP ratios in the year 1992. Hence, we show within the error-correction approach that the introduction of the Maastricht Treaty and the Stability and Growth Pact is negatively related with the change in the budgetary imbalance. As a conclusion, the introduction of EU

fiscal policy criteria is relevant institutional change which encourages the fiscal sustainability in the EU member countries over the sample under study. Hence, we evidence that the time of parliamentary elections is an significant explanatory factor of increased fiscal imbalance (*Hypothesis 4*).

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Appendix A

		ADF test			PP test			DF-GLS test		
		Model with constant	Number of lags	First Diffe-rences	Model with constant	Number of lags	First Diffe-rences	Model with constant	Number of lags	First Diffe-rences
AUT	D_t	-2.74*	1	-4.79***	-2.24	4	-5.31***	-1.74*	0	-4.74***
	B_t	-1.65	0	-3.48***	-1.51	4	-3.37**	-0.69	1	-3.11***
BEL	D_t	-1.06	2	-3.08**	-1.21	4	-6.44***	-1.15	2	-2.87***
	B_t	-1.85	1	-1.70	-1.40	4	-1.66	-1.54	1	-1.74*
DNK	D_t	-2.804*	1	-3.93***	-2.05	4	-3.85***	-2.39**	1	-3.77***
	B_t	-2.24	1	-2.32	-1.62	4	-2.36	-1.69*	1	-2.32**
FIN	D_t	-2.48	1	-4.27***	-2.03	4	-4.15***	-2.46**	1	-4.34***
	B_t	-0.97	2	-3.90***	-0.93	4	-2.51	-081	2	-3.86***
FRA	D_t	-1.95	0	-5.07***	-1.97	4	-5.04***	-1.36	0	-5.10***
	B_t	0.66	4	-4.25***	-0.149	4	-2.48	0.15	1	-4.37***
GER	D_t	-3.65***	1	-5.60***	-3.25**	4	-6.81***	-2.70**		-5.68***
	B_t	-0.08	0	-4.24***	-0.18	4	-4.18***	0.22	1	-4.11***
GRE	D_t	-1.95	0	-6.95***	-1.92	4	-6.89***	-1.36	0	-6.87***
	B_t	-0.41	0	-5.19***	-0.50	4	-5.32***	-1.43	4	-1.59
IRL	D_t	-0.57	2	-4.62***	-0.78	4	-4.31***	-0.79	0	-4.69***
	B_t	-1.15	1	-2.70*	-0.84	4	-2.68***	-1.15	1	-2.73***
ITA	D_t	-2.13	4	-2.28	-1.53	4	-6.67***	-1.79	4	-1.67*
	B_t	-1.41	1	-2.77*	-1.66	4	-2.79*	-0.57	1	-2.68***
LUX	D_t	-4.23***	0	-5.36***	-4.42***	4	-12.83***	-4.19***	0	-5.46***
	B_t	-3.32**	0	-3.22**	-3.25**	4	-3.79***	-0.71	0	-3.26***
NETH	D_t	-2.01	0	-5.74***	-2.01	4	-5.80***	-1.97**	0	-5.83***
	B_t	-3.46**	3	-1.87	-1.59	4	-1.94	-1.69*	1	-1.90*

Table 1:   Tests for Unit Root and Stationarity

		Table 1: Tests for Unit Root and Stationarity							
PRT	D_t	-2.74	0	-6.31***	-2.70*	4	-6.42***	-1.65*	0	-6.41***
	B_t	-2.20	0	-5.09***	-2.28	4	-5.17***	-0.70	0	-4.43***
ESP	D_t	-1.44	0	-5.31***	-1.67	4	-5.39***	-1.18	0	-4.71***
	B_t	-1.38	1	-2.60	-1.14	4	-2.73*	-1.08	1	-2.64***
SWE	D_t	-3.13**	1	-3.53**	-2.34	4	-3.52**	-3.01***	1	-3.55***
	B_t	-2.37	1	-2.40	-1.66	4	-2.55	-1.96*	1	-2.44**
UK	D_t	-3.81***	3	-4.05***	-2.81*	4	-3.67***	-2.51**	1	-3.68***
	B_t	-3.25**	4	-3.89***	-2.49	4	-2.55	-1.40	1	-3.58***

All variables are measured in relation to GNP. D_t denotes the primary budget deficit-GDP ratio, and B_t is the market value public debt-GDP ratio. The values are the estimated t-statistics.. '**', '*' or '(*)' show that the corresponding null hypothesis can be rejected at the 1, 5, or 10 percent level, respectively. The number of lags of the ADF test has been determined using the Hannan-Quinn criterion. For the PP always 4 lags have been used.

	Table 2: Panel Unit Roots Tests								
	LL-test			IPS-test			Fisher ADF-test		
Variables	Model with constant	Number of lags	First Differences	Model with constant	Number of lags	First Differences	Model with constant	Number of lags	First Differences
D_t	-2.34	8	8 -11.58***	-3.91	8	8 -10.78***	-3.83	8	8 -9.76***
B_t	-2.61	5	3 -5.57***	-0.73	5	3 -7.84***	-0.64	5	3 -7.49***

All variables are measured in relation to GNP. D_t denotes the primary budget deficit-GDP ratio, and B_t is the market value public debt-GDP ratio. The values are the estimated t-statistics.. '**', '*' or '(*)' show that the corresponding null hypothesis can be rejected at the 1, 5, or 10 percent level, respectively.

Table 3: Results of the Engel-Granger Cointegration Test						
	Cointegrating equation			Residual regression		
Dependent variable	$\hat{\beta}$	R^2	SE	D.-W.	k	ADF-statistic
AUT						
D_t	0.05***		0.01	0.48	0	-2.1
		0.27				
B_t	5.05***		0.15	0.10	0	-0.56
BEL						
D_t	0.01		0.04	0.16	2	-1.01
		0.01				
B_t	0.66		0.29	0.026	1	-1.84
DNK						
D_t	0.06***		0.027	0.39	1	-2.65
		0.26				
B_t	3.88***		0.20	0.12	1	-1.61
FIN						
D_t	0.14***		0.02	0.49	1	-2.50
		0.47				
B_t	3.39***		0.13	0.19	0	-1.07
FRA						
D_t	0.04**		0.01	0.48	2	-3.21**
		0.22				
B_t	4.73**		0.13	0.10	6	1.30
GER						
D_t	0.02*		0.01	0.98	0	-3.46**
		0.07				
B_t	2.75*		0.14	0.07	0	-0.49
GRE						
D_t	0.05***		0.03	0.27	0	-1.77
		0.22				
B_t	4.14***		0.36	0.06	0	-0.21
Table 3: Results of the Engel-Granger Cointegration Test						
IRL						
D_t	0.08**	0.20	0.04	0.15	1	-1.27

B_t	2.39**		0.23	0.07	1	-1.23
ITA						
D_t	-0.02	0.04	0.03	0.23	4	-2.26
B_t	-1.59		0.27	0.04	1	-1.92*
LUX						
D_t	0.43**	0.20	0.04	1.83	0	-5.29***
B_t	0.46**		0.04	0.47	0	-3.11**
NETH						
D_t	0.04*	0.09	0.01	0.47	0	-1.92
B_t	2.06*		0.12	0.08	3	-2.22
PRT						
D_t	0.05*	0.09	0.02	0.65	0	-3.03**
B_t	1.74*		0.13	0.08	1	-1.82
ESP						
D_t	0.05***	0.22	0.02	0.20	0	-1.10
B_t	3.93***		0.17	0.04	0	-0.26
SWE						
D_t	0.13**	0.18	0.04	0.35	2	-3.22**
B_t	1.34**		0.14	0.09	1	-1.72
UK						
D_t	-0.005	0.006	0.02	0.39	2	-3.66**
B_t	-0.10		0.11	0.07	4	-3.13**

All variables are measured in relation to GNP. D_t denotes the primary budget deficit-GDP ratio, and B_t is the market value public debt-GDP ratio. The values are the estimated t-statistics.. '**', '*' or '(*)' show that the corresponding null hypothesis can be rejected at the 1, 5, or 10 percent level, respectively.

Table 4: Results of the Pedroni Panel Cointegration Test						
	Cointegrating equation			Residual regression		
Dependent variable	$\hat{\beta}$	R^2	D.-W.	k	Panel t-statistic (parametric)	Group t-statistic (parametric)
D_t	0.05*** (0.007)	0.44	0.46	2	-2.06	-3.84
B_t	1.88*** (0.26)	0.56	0.06	5	-1.45	0.02
All variables are measured in relation to GNP. D_t denotes the primary budget deficit-GDP ratio, and B_t is the market value public debt-GDP ratio. The values are the estimated t-statistics.. '**', '*' or '(*)' show that the corresponding null hypothesis can be rejected at the 1, 5, or 10 percent level, respectively. k is the number of lags of the ADF test.						

Table 5: Error-correction model for the panel of 15 European Union member countries:

Dependent variable: first difference of the consolidated budget deficit (percent of GDP), $\Delta D_{t,i}$

Variables	Coeff. (t-stat.)	Coeff. (t-stat.)	Coeff. (t-stat.)	Coeff. (t-stat.)	Coeff. (t-stat.)	Coeff. (t-stat.)	Coeff. (t-stat.)	Coeff. (t-stat.)	Coeff. (t-stat.)
$\Delta B_{t,-1,i}$	0.05* (1.99)	0.05** (2.20)	0.05** (2.23)	0.05** (2.15)	0.05** (2.23)	0.05** (2.01)	0.05** (2.01)	0.05** (1.95)	0.05* (1.99)
$\Delta D_{t,-1,i}$	0.08** (2.14)	0.08** (2.17)	0.08** (2.16)	0.09** (2.35)	0.09** (2.32)	0.09** (2.41)	0.09** (2.40)	0.10** (2.61)	0.10** (2.59)
$\hat{\varepsilon}_{i,t-1}$	-0.19*** (5.11)	-0.23*** (6.35)	-0.23*** (6.37)	-0.23*** (6.40)	-0.24*** (6.46)	-0.26*** (6.80)	-0.26*** (6.79)	-0.26*** (6.82)	-0.26*** (6.83)
Constant	-0.002 (0.75)	0.002** (2.56)	0.002* (2.50)	0.001 (1.27)	0.00 (0.56)	0.001** (2.02)	0.001* (1.76)	0.000 (0.48)	-0.000 (0.09)
Maastricht Treaty Dummy	-	-0.006*** (4.92)	-0.006*** (4.95)	-0.006*** (4.89)	-0.006*** (4.91)	-	-	-	-
SGPD Dummy	-	-	-	-	-	-0.009*** (5.10)	-0.009*** (5.08)	-0.008*** (4.95)	-0.008*** (4.85)
Fed. Structure Dummy	-	-	-0.00 (0.65)	-0.00 (0.59)	-0.00 (0.07)	-	-0.00 (0.11)	-0.00 (0.28)	0.000 (0.32)

Table 5: Error-correction model for the panel of 15 European Union member countries:

Dependent variable: first difference of consolidated budget deficit (percent of GDP), $\Delta D_{t,i}$								
Election Year Dummy	-	-	-	0.004*** (3.03)	0.004*** (3.09)	-	-	0.004*** (3.13)	0.004*** (3.20)
Majoritarian System Dummy	-	-	-	-	0.002 (1.20)	-	-	-	0.001 (0.94)
Country-Fixed Effect	Yes	No	No	No	No	No	No	No	No
R^2	0.46	0.48	0.48	0.48	0.48	0.47	0.48	0.48	0.47
DW-statistics	1.94	1.97	1.97	1.96	1.97	1.92	1.91	1.91	1.92
JB-statistics		5.18	5.44	6.20	6.20	4.31	5.04	5.17	5.44
F-test: $H_0 : \hat{\beta} = 0$								
$\beta_{\Delta TD_{t-1,i}}$	3.48**	4.85**	5.01**	4.65**	5.01**	5.06**	4.07**	3.96**	2.85
$\gamma_{ECTt-1,i}$	26.53***	40.34***	40.62***	41.02***	41.76***	46.25***	46.16***	46.67***	42.60***
$\beta_{Maastricht}$	-	24.28***	24.52***	23.95***	24.17***	-	-	-	-
β_{SGP}	-	-	-	-	-	26.05***	25.84***	24.52***	23.55***

All variables are measured in relation to GNP. D_t denotes the primary budget deficit-GDP ratio, and B_t is the market value public debt-GDP ratio. The values are the estimated t-statistics.. '**', '*' or '(*)' show that the corresponding null hypothesis can be rejected at the 1, 5, or 10 percent level, respectively.

Appendix B:

Data and sources for 15 countries over the period 1970-2004

Time series	Sources
General government public debt (in national currency)	*AMECO*: Code UDGGL
Price deflator of final private consumption expenditure	*AMECO*: Code PCPH
General government total revenues (in national currency)	*AMECO*: Code URTG (ESA 1995) and URTGF
General government total expenditures (in national currency)	*AMECO*: Code UUTG (ESA 1995) and UUTGF
Gross domestic product (at marked prices)	*AMECO*: Code UVGDH (ESA 1995) and UVGD

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