# Analysing Economic Growth and Debt Relationship in a Panel of European Countries

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**Abstract:** The idea that public debt has a negative impact on economic growth has been very popular in literature, and it has been the guide towards the adoption of policies of debt reduction. Through empirical and theoretical models, many studies have attempted to provide support for this claim and for the existence of general debt thresholds above which debt would negatively affect growth. However, because of heterogeneous conditions, it is unlikely that such thresholds could be generalized to any country and any period.

Going beyond the estimation of debt-thresholds, our work aims to deepen the relationship between public debt and economic growth by analysing a slightly unbalanced panel data set with 25 Western and Eastern European countries, with quarterly data from 1999Q1 to 2015Q4. After testing for unit roots, we perform a cointegration analysis both at country and panel level to understand for which countries a cointegration relationship between GDP and debt exists, and thus for which countries of our data set a long-run relationship between these variables can be described. Then, we specify a panel-VAR model to compare our groups of countries, and finally we decompose GDP into its main subcomponents to find out whether or not cointegration arises at the aggregate level only.

Our findings show that a) a long-run relationship between public debt and GDP exists for some countries but it cannot be generalized, and b) the short-run linkage between public debt and GDP is negative, but it is determined by the events that follow the financial crisis.

**Key words**: Economic growth, Public debt, Cointegration analysis.

# 1 Introduction and related literature

## 1.1 The pursuit of the *debt threshold*

The empirical interest in the debt-growth relationship abruptly emerged at the end of the 2000s. Starting with the financial crisis of 2008 and then with the debt crisis in the Eurozone, those countries in the European Monetary Union (EMU) with a high debt-to-GDP ratio have faced a dramatic worsening in their debt sustainability as perceived by the market. Some governments have coped with this situation by implementing a set of restrictive fiscal policies, whose aim was to reduce government budget deficits and outstanding public debts that were considered no longer sustainable and a burden on the future growth of the economies.

One of the main supports for the implementation of these corrective measures came from the influential paper by Reinhart and Rogoff (2010), whose main finding is a negative relationship between growth and debt above a general threshold of 90 percent of the debt-to-GDP ratio. Although Reinhart and Rogoff's work (2010) was deeply criticized, first by Irons and Bivens (2010) for what regards the applicability of the analysis to U.S. and the implied causality[1], and then by Herndon et al. (2013) for the methodology[2], it has sparked a wave of studies searching for debt thresholds in advanced countries: the pursuit of the general *debt threshold* above which growth is jeopardised by public debt.

Taking a step back, before the financial crisis the empirical research focus was essentially on poor and developing countries. This literature was supported by the debate around the debt cancellation programs, that becomes popular since the 80s (see for instance Krugman (1988)). In this vein, by employing a large panel data set of developing countries, Pattillo et al. (2011) has found a threshold for the debt-to-GDP ratio of 35-40 percent, above which growth is negatively affected, and a negative marginal impact of debt on growth even at a half of this estimated threshold. Second, by employing spline interpolation, the authors have found the existence of a non-linear relationship between the two variables. Third, they have argued that the investments level is not the main channel through which excessive external debt affects growth[3]. Nguyen et al. (2003) has reached a similar conclusion for low-income countries by arguing that a level of internal debt above 50 percent of GDP[4] can negatively affect growth because of an inefficient use of the available resources.

In the more recent post-crisis literature, the debt-growth debate has changed perspective by hinging the analysis on high-income countries and, in particular, on EMU's members and their constraints. Even though the most popular idea is that there is a negative relationship between debt and growth (and that negative effects arise earlier for poor countries than for rich countries), empirical results can actually be divided into three categories: 1) Public debt jeopardizes growth above a certain threshold of the debt-to-GDP ratio; 2) Public debt has no effects on growth above a certain threshold; and 3) Public debt has a positive effect on growth above a certain threshold.

The first group includes the majority of the threshold-based works, and it is not possible to list

[1]Their application of the Granger causality test have showed that debt does not cause growth and growth does not cause debt.

[2]The analysis was spoiled by coding errors, selective exclusion of available data, and unconventional weighting of summary statistics.

[3]This statement is known as the *Neoclassical crowding-out effect*. For a theoretical discussion, see for instance Bernheim (1989) and Hemming et al. (2002).

[4]Or above 20-25 percent if its net present value is considered.

all of them here. Caner et al. (2010) performed a comparison between developing and developed countries. By employing a large dataset of 99 countries, it has showed that growth is negatively affected above 77 percent of the long-run debt-to-GDP ratio, and above 64 percent if only developing countries are considered. The same conclusions have been reached by Cecchetti et al. (2012) (which has identified a threshold at the 84 percent of GDP and at 96 percent of GDP when a control variable for crisis periods is added) and by Afonso and Jelles (2013) (which has found a negative impact of debt on growth, besides an effect of worsening of financial crises above a threshold of 90 percent of GDP).

A group of studies has attempted to better describe the whole relationship. Baum et al. (2012) has showed that, on the basis of a data set including 12 EMU countries from 1980 to 2008, the short-run impact of debt on growth is positive and statistically significant for low levels of debt-to-GDP, but decreases and eventually has a negative impact above a threshold of 95 percent. It has also pointed out that the long-term bond interest rate is subject to an increased pressure when the debt-to-GDP ratio is above 70 percent. Checherita-Westpahl and Rother (2012) has employed an extended data set to the period 1970-2010 to show that the relationship linking debt and growth is concave and U-shaped, with a turning point around 90-100 percent of GDP, and the existence of such a relationship has been ascribed to public investments and total factor productivity. Finally, in another paper, Checherita-Westphal et al. (2012) proposed a theoretical explanation for the U-shaped relationship[5].

At the same time, other studies reached the conclusion that no relationship seems to link debt and growth. Cordella (2010), Egert (2015), and Presbitero (2012) have showed that a non-linear relationship exists, but debt becomes irrelevant for high levels of debt-to-GDP ratio. Presbitero (2012) explained these findings referring to country-specific factors, sample composition and to the fact that "debt overhang is a growth constraint only in countries with sound macroeconomic policies and stable institutions" (Presbitero, 2012:1). In another work, Eberhardt and Presbitero (2015) claimed that, by applying a standard Error Correction Model[6] (ECM) and accounting for heterogeneity, a non-linear relationship between debt and GDP across-countries actually arise[7]. However, a systematic within-country relationship has not been found and a general debt-to-GDP threshold has been deemed to be unlikely to exist.

Summing up all the contributions, it is difficult to derive a unified thinking and it seems that heterogeneous conditions do not allow to derive a general relationship between growth and debt. Leaving aside the paper by Reinhart and Rogoff (2010) and its direct critiques, the majority of the studies supported the view that debt jeopardizes growth above a certain thresholds (but there is no agreement on its level), whereas other authors found no evidence about the existence of such a threshold. Finally, some authors supported the existence of a positive relationship above a certain threshold (see Minea et al., 2012, according to which debt reduces growth for values of debt-to-GDP ratio below a threshold of 115 percent, but this effect disappears and becomes positive above that threshold).

[5]Greiner (2012) has criticized this conclusion. Specifically, it claimed that the model was based on a very simple and unrealistic fiscal policy with exogenously fixed deficits, and that "once a more general debt policy is considered, one finds that smaller public deficits and lower public debt always generate a higher growth rate" Greiner (2012:6).

[6]See Appendix A for further details

[7]It must be underlined that, in this study, debt has been regarded as exogenous with respect to growth.

In general, a debt threshold may be useful from a political and institutional perspective, but, because of heterogeneity, it would be optimistic to believe that such a threshold could be applied to any country in any period. This is exactly the conclusion presented in Chudik et al. (2015). Based on a data set of advanced and emerging countries, the research has not found any evidence about a general debt threshold. However, authors showed that this conclusion does not compromise the existence of a long-run negative relationship between rising public debt and growth, suggesting that "the debt trajectory can have more important consequences for economic growth than the level of debt-to-GDP itself" (Chudik et al. 2015:28). In conclusion, the value of the debt-to-GDP ratio at a given point in time is perhaps too narrow a variable to explain such a complex thing as growth.

## 1.2 Beyond thresholds: a general causal relationship involving debt and growth

Without estimating specific debt thresholds, other authors have attempted to study the debt-growth linkage from an empirical point of view. Deshpande (1997) has explicitly dealt with the Neoclassical claim that public debt crowds out investments but, unlike Nguyen et al. (2003), it considered external debt only. With a data set that includes 13 countries characterized by high debt-to-GDP ratios, external debt was found to exercise a negative impact on investments. In the same vein, Balassone et al. (2011) has used Italian data from 1861 to 2009 to show that the negative relationship between public debt and growth is mainly due to the negative impact of debt on the investment level. Evidence about the existence of a negative relationship is also supported by Ceh Casni et al. (2014) (whose analysis has been based on Central, Eastern, and Southeastern European countries data) and in Bordo et al. (2010) (in which, by exploiting a data set of developing countries, "both hard currency debts and capital inflows are associated with crises that lower growth temporarily and permanently reduce output compared to the long-run trend", Bordo et al. 2010:661). A different methodology has been proposed by Panizza and Presbitero (2014), that initially confirmed the existence of a negative relationship between debt and growth but, once an instrumental variable for the public debt based on the exchange rate was introduced, the linkage between the two variables disappeared. These authors have explicitly excluded causality after the inclusion of the instrumental variable, a conclusion in line with Irons and Bivens (2010), cited in the previous section.

A deeper analysis of causality was performed by Kumar and Woo (2015) by adopting a panel data set of both advanced and emerging economies. This study has accurately considered the intertemporal nature of the relationship, examining the influence that the public debt has on the growth rate of the subsequent five to twenty years. The analysis has suggested the existence of a negative relationship between the initial debt and the subsequent growth or, in other words, "a 10 percentage point increase in the initial debt-to-GDP ratio is associated with a slowdown in real per capita GDP growth of around 0.2 percentage points per year, with the impact being somewhat smaller in advanced economies" (Kumar and Woo, 2015:25).

Finally, Lof and Malinen (2014) has proposed a panel VAR analysis on the stationary growth rates of debt and GDP of 20 advanced countries, and it has reached opposite conclusions to Kumar and Woo (2015): debt has no statistically significant effects on growth but, in fact, growth has a statistically significant negative effect on public debt. In other words, the negative correlation between debt and

growth is due to the negative impact that growth has on debt.

As before, it is difficult to derive a univocal conclusion for econometric analyses and it is not easy to solve the causality direction dilemma. Even when it is recognized that a general debt threshold for economic growth is unlikely to exist, results about the nature or the direction of the causal effect do not agree. In any case, the existence of a significant negative relationship between debt and growth is the predominant thinking, although in contrast with the conclusions of a long list of theoretical works. Thus, it is important to understand not only if debt and growth are somehow linked, but also whether public debt has a long-term negative impact on growth. This is the main goal of this study, which is organized in the following way: firstly it analyses whether a long-run linkage between GDP and public debt exists by performing a cointegration analysis (section 2) from which general implications are inferred though panel models (section 3), and then it attempts to go in depth by decomposing GDP into its subcomponents (section 4).

# 2 Does a long-run relationship exist?

## 2.1 Methodology

In order to describe the long-run relationship between GDP and public debt, we have employed a cointegration analysis both at country and at panel level. The presence of cointegration implies that, even though the two variables are integrated, a linear combination of them is stationary, i.e. they share a common stochastic trend. In this case, it is possible to rewrite the model to identify a long-run component and a short-term adjustment.

At country level, the Johansen trace test statistic (see Johansen, 1991) has been applied to determine the cointegration rank. The estimated VAR model reformulated in error correction terms is, for each country:

$$\Delta X_t = \Pi X_{t-1} + \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{k-1} \Delta X_{t-k+1} + \Phi_1 D_t + \epsilon_t \tag{1}$$

where $t = 1, ..., T$ indicates time periods, $X_t$ is a squared $N \times N$ matrix including the $N$ variables of interest (in our case there are two variables, the logarithms of the public debt and of the GDP), $k$ is the number of lags, $D_t$ is a vector of deterministic variables containing a constant term, a linear trend and, eventually, seasonal dummies, and $\epsilon_t \sim iid\, N_T(0, \Omega)$ are error terms. In model 1, the matrix of interest is $\Pi$: if the rank of $\Pi$ is $R < N$, then $R$ cointegration relationships exist and $\Pi$ can be decomposed into the product of two $N \times R$ matrices, $\alpha\beta'$, with a stationary product $\beta' Y_t$. Matrix $\alpha$ includes the adjustment parameters, which determine the speed of convergence towards the long-run relationships, while matrix $\beta$ includes the cointegration vectors.

In our specific case, the estimated model assumes the form of a *Restricted Linear Trend Model*, which allows the cointegration relationships to have a constant and to be trend stationary; this model is appropriate because we do not know *a priori* whether the trends in our variables cancel out in the cointegration relationships. Following Dennis (2006:6), this model is derived from equation (1) and can be written as:

$$Z_{0t} = \alpha\beta' Z_{1t} + \Psi Z_{2t} + \epsilon_t \tag{2}$$

where $Z_{0t} = \Delta X_t$, $Z_{1t} = \begin{bmatrix} X_{t-1} \\ D^R_{t-1} \end{bmatrix}$, $Z_{2t} = \begin{bmatrix} \{\Delta X_{t-i}\},\ i = 1, ..., k-1 \\ D^U_t \end{bmatrix}$, $\Psi$ includes $\Gamma_1, ..., \Gamma_{k-1}$, and $D^R_{t-1} = t$, $D^U_t = 1$. For what regards the analysis at panel level, we have applied Pedroni tests (see Pedroni, 1999) and Westerlund tests (see Westerlund, 2008). As explained in Section 1.2, the interest is in the relationship between them.

When cointegration has been detected and in order to give an interpretation to the cointegration relationship, we have tested for each country the stationarity of an imposed homogeneous relationship between the two variables. In details, the equilibrium relationship between debt and GDP can be extensively written as:

$$\beta_1 ln(DGG_t) + \beta_2 ln(GDP_t) + \beta_3 T_{first-break} + \beta_4 T_{second-break} + \beta_5 Trend = u_t \tag{3}$$

and, by imposing the coefficients of $ln(DGG_t)$ and $ln(GDP_t)$ to be 1 and -1 respectively:

$$ln(DGG_t) - ln(GDP_t) + \beta_3 T_{first-break} + \beta_4 T_{second-break} + \beta_5 Trend = u_t \tag{4}$$

$$ln\left(\frac{DGG_t}{GDP_t}\right) = u_t - \beta_3 T_{first-break} - \beta_4 T_{second-break} - \beta_5 Trend \tag{5}$$

Since we can rewrite $(ln(DGG_t) - ln(GDP_t))$ as $ln(DGG_t/GDP_t)$, equation (4) describes in fact the evolution of the logarithm of the debt-to-GDP relationship. In other words, whenever the corrected p-values do not allow to reject the imposed restriction on the cointegration vector at the usual 5 percent significance level, i.e. $H_0 : \beta = (1, -1, \beta_3, \beta_4, \beta_5)$, the cointegration relationship can be interpreted as the debt-to-GDP ratio; on the contrary, whenever this restriction is statistically rejected, the "pure" debt-to-GDP ratio does not represent the long-run relationship between debt and GDP.

## 2.2 Data set description

Our analysis is based on a slightly unbalanced panel data set including quarterly data for 25 Eastern and Western European countries[8]. Annual data were inadequate for our scope both because available time series include relatively less observations than quarterly time series, and because some links between the two variables could not arise in low frequency data.

The two main variables of the data set are the gross domestic product and the general government public debt, both expressed at constant prices[9]. Constant prices time series are necessary in order to leave aside inflation and to accurately identify the long-run relationship. Data about GDP cover

[8] Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and UK.

[9] Obtained by dividing the current values by the GDP deflator (2010=100).

the period from 1999Q1 to 2015Q4 and they have been adjusted for seasonality by applying the X-13 ARIMA[10] technique. The seasonal adjustment and the logarithm transformation allow respectively to exclude seasonal cycles and misleading phenomena, and to reduce the volatility of the time series. For the majority of countries, data about public debt cover the period from 2000Q1 to 2015Q4 and have been adjusted for seasonality only when seasonality was previously identified. Overall, there are 1700 observations for the GDP and 1612 observations for the public debt. Whenever a strongly balanced data set is required for the analysis, a reduced data set to the period 2000Q1-2015Q4 has been employed. Table 1 in Appendix summarizes the structure of our data set. All countries have experienced a decline in the GDP because of the crisis, but the greatest changes occurs in the debt levels of some countries (e.g. Bulgaria, Greece, Ireland, Latvia, Spain).

From these time series, the growth rates have been obtained. They are represented in Figure 1, while their summary statistics are shown in Table 2 jointly with the correlation coefficient. Apart from the negative growth rates experienced by the countries during the financial crisis, the GDP growth rates' dynamics look to be more stable than the debt growth rates. Furthermore, though a non-zero correlation coefficient does not imply a relationship between the variables, even less a causal relationship, it is interesting to observe that correlation coefficients are different from zero in the majority of cases (19 countries out of 25 show a correlation coefficient greater than 0.1 in absolute value), but the sign is almost always negative, reflecting the fact that to a positive variation in one variable corresponds a negative variation in the other.

The Spearman's rho, less sensitive to outliers and used to capture whether a variable is a monotone function of the other, is also almost always negative. More important, Spearman's coefficients are always far from 1 and -1, thus indicating that a decreasing monotonic trend between GDP and debt exists but it is generally weak. Finally, the Kendall's tau, which captures the rank ordinal association between the two variables, does not show a strong ordinal correlation between the two variables.

In order to check whether a general intuition can be derived for the whole panel, the scatter-plot of all the growth rates has been represented in Figure 2. In line with the graphs proposed by Eberhardt and Presbitero (2012) or by Herndon et al. (2013), no clear relationship emerges from it. The regression line is slightly downward sloping but this result is clearly determined by few outliers. In fact, when these observations are removed, the linear regression line becomes almost flat. Figure 3 combines the two series into the well-known debt-to-GDP ratio that, with quarterly data, assumes different values than with yearly data. The distributions of the debt-to-GDP ratio among countries are different both in terms of level and in terms of dispersion, but what arises is a general positive skewness, with the right tail longer than the left tail for almost any country.

In the following paragraphs we attempt to look for a long-run relationship between debt and GDP but, for the moment, the graphical analysis does not allow to derive any hint about the existence of such a relationship. By looking at the correlation coefficients the two series seem to be correlated, but by looking at the scatter-plot of the growth rates no clear relationship arises. Moreover, the boxplots representing the distributions of the debt-to-GDP ratio lead to identify a great degree of heterogeneity between the countries.

[10]Provided by the X13 U.S. Census Bureau software.

## 2.3 Country-level cointegration analysis

Time series have been studied with two sets of tests: unit-root tests, to determine whether the series are stationary, and cointegration tests, to determine whether a linear combination is stationary, even in the case in which they are individually non-stationary. The analysis has been performed with Matlab R2015b and CATS 2.0.

The unit-root analysis has been used for each country to find out the order of integration of each time series. The augmented Dickey and Fuller test (ADF) and the KPSS test have been performed and both have confirmed that GDP and debt can be considered as non-stationary I(1) series[11]. Therefore, a cointegration analysis has been carried out and the detailed results are reported in Table 3. By looking at it, the columns denoted by *Parameters* show the number of lags included, whether there are one or more significant breaks, and whether centered seasonal dummies or other dummies have been included. This part corresponds to the choice of the model, done by selecting the maximum number of lags through the AIC/FPE criterion, and then adjusting it by looking at the tests on residuals (*Autocorrelation* - LB, LM(1) and LM(2) tests - and *Normality* columns) and by including, eventually, appropriate dummy variables. Finally, the columns *Test on restricted model* show the p-values and the corrected p-values of the significance tests performed on the imposed restriction on $\beta$[12] (see Section 2.1).

The main results of the analysis are reported in the two columns denoted by *Cointegration rank*, where the p-values and the corrected p-values[13] of the Johansen trace test are reported. At the significance level of 5 percent, 14 countries show no cointegration: Belgium, Bulgaria, Czech Republic, Estonia, Finland, Greece, Ireland, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, UK. For all the other countries one cointegration relationship has been detected. Therefore, countries can be divided into at least two groups, those that show cointegration and those that do not show cointegration, though on the basis of different econometric models (thus implying different equilibrium relationships between debt and GDP). In order to give an interpretation to these relationships, the coefficients of $ln(DGG_t)$ and $ln(GDP_t)$ have been subsequently set to 1 and -1 respectively, as explained in Section 2.1, and the resulting estimated debt-to-GDP relationships ($ln(DGG_t/GDP_t)$) are shown in Figures 4, 5, and 6. This restriction cannot be statistically accepted for every country in

[11]The ADF test for unit-root has been performed with the inclusion of a number of lags from 0 to 8. Results show that the null-hypothesis of unit-root cannot be rejected at 5 percent level for the two variables, both in the basic case and in the trend-stationary case. Therefore, ADF test suggests that GDP and debt are non-stationary. The number of country-observations is not small, but this result could have been determined by the impossibility to reject the null-hypothesis because of the lack of enough information in the time series. Therefore, as a comparison for the ADF test, a KPSS test has also been performed, with the inclusion of the same number of lags considered for the ADF test. Results are slightly less favourable to the non-stationary hypothesis: in fact, for the GDP case, the presence of a unit-root has been confirmed at a significance level of 5 percent for all countries except France and Ireland (for more than 2 lags), while, for the debt case, the test does not allow to reject the null at a significance level of 5 percent for Estonia and Czech Republic (respectively for more than 3 and 4 lags). The analysis has been repeated for the growth rates of the GDP and of the public debt respectively. The results of the ADF and KPSS tests generally agree at 5 percent level, and the time series of the two growth rates can be regarded as stationary. Given these results and by looking at the p-values corresponding to the number of lags suggested by the AIC/FPE criterion, we decided to consider all the series as I(1).

[12]The null is not rejected for Austria, Belgium, Denmark, Italy, Latvia, Luxembourg, Sweden, and Slovenia.

[13]The p-values based on the Bartlett correction for small sample sizes are also reported - See Johansen (2002).

the cointegration group[14], thus underlying the fact that the long-run relationship cannot be always described as the debt-to-GDP ratio. Moreover, by looking at the outliers around 2008 and 2009 in the second graph of each figure, it is clear how the estimated models are unable to fully capture the impact of the financial crisis, which will be explicitly considered below.

Finally, it has been analysed whether debt or GDP can be treated as weakly exogenous, an analysis that has not often been done in other studies. In fact, for some countries, either debt or GDP can be considered as weakly exogenous, thus implying that debt cannot be considered as an independent variable for every country[15] and that, in this circumstance, a single-equation model is appropriate.

In conclusion, the existence of a cointegration relationship between debt and GDP cannot be generalized, as well as the existence of a unique model for every country. Moreover, on the basis of these findings and without relying upon the debt-to-GDP thresholds, it is possible to divide the countries in the data set into four groups, that will be used to analyse the GDP-debt relationship in the following section:

1. Cointegration, debt is weakly exogenous: Cyprus, France, Italy;

2. Cointegration, neither GDP nor debt is weakly exogenous: Austria, Denmark, Germany, Hungary, Latvia, Lithuania, Luxembourg, Sweden.

3. No cointegration, debt is weakly exogenous: Belgium, Bulgaria, Estonia, Finland Czech Republic, Ireland, Greece, Netherlands, Portugal, Slovakia.

4. No cointegration, neither GDP nor debt is weakly exogenous: Romania, Slovenia, Spain, UK.

## 2.4 Panel-level cointegration analysis

In order to identify a general debt-GDP relationship, it is worthwhile to work at panel level instead of at country level. Thus, the unit-root analysis and the cointegration analysis have been carried out again by employing the panel statistics available in Stata 13. Panel unit-roots tests, Im-Pesaran-Shin (IPS), Fisher-type ADF, Breitung test and Harris-Tzavalis test confirmed the fact that the time series are I(1)[16]. Therefore, two cointegration tests have been performed to detect cointegration at

[14]In particular, it is accepted at the 1 percent level for Austria, Cyprus, Hungary, Italy, and Luxembourg.

[15]At the 5 percent significance level, debt can be treated as weakly exogenous for Belgium, Bulgaria, Cyprus, Czech Republic, Estonia, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal, Slovakia. For the remaining countries, i.e. Austria, Denmark, Germany, Hungary, Latvia, Lithuania, Luxembourg, Romania, Slovenia, Spain, Sweden, an UK, neither debt nor GDP can be considered as weakly exogenous.

[16]The IPS test explicitly allows to work with an unbalanced data set. It verifies the null-hypothesis that all panels contain a unit-root against the alternative hypothesis that at least one panel is stationary. This test has been performed without the inclusion of a time trend and with 0, 1, 2, 3, and 4 lags. As expected, at a confidence level of 5 percent the null hypothesis is never rejected for the public debt. The same is true for the GDP but, for the 1 lag case, p-values allow rejection only at 1 percent level. These results are confirmed by the Fisher-type ADF test and even with the inclusion of a time trend. These conclusions are confirmed by other two tests, the Breitung test and the Harris-Tzavalis test, that are based on the strong hypothesis that all panels share the same autoregressive parameter. These tests, that allow to introduce two corrections for panel data, require a balanced panel; therefore, they have been applied to the reduced dataset 2000Q1-2015Q4. The first test does not reject the null of unit-root for every panel even when sectional dependence is allowed, while the latter does not reject the null of unit-root for every panel even when the small time-period sample adjustment is introduced. In conclusions, it seems reasonable to consider GDP and debt as non-stationary for every country

panel-level: Pedroni tests and Westerlund ECM tests, whose results are shown in Appendix, Table 6[17]. Conclusions, however, do not agree. On the one hand, Westerlund tests always accept the null of no cointegration: they do not detect cointegration neither at panel level (correctly) nor at group level, when countries have been grouped according to the four categories identified at the end of the previous section. On the other hand, Pedroni tests always accept the null of no cointegration when a time trend is included but, without a time trend, some of the seven tests lead to the rejection of the null while others lead to its acceptance. Only for the fourth sub-panel (no cointegration with no weakly exogenous variables) the test statistics all agree with the country-level tests.

On the basis of these results it is impossible to use panel tests to confirm the country-level results. Probably, the reason lies in the fact that the latter do not allow the same level of details of the country-level tests: panel tests require one variable to be weakly exogenous with respect to the other, and it is not possible to include breaks in the trend component.

# 3 Dynamic panel estimation

In the previous sections four groups of countries have been identified according to the existence of a cointegration relationship and to the weak exogeneity of one variable with respect to the other. The existence of a cointegration relationship implies a long-run relationship between debt and GDP but it does not say anything about the nature of such a relationship and about the sign of the short-run adjustments. In order to compare the groups of countries and attempting to derive general implications, four error-correction models have been estimated by employing panel dynamic techniques[18]. Results are shown in Table 7.

Column (1) and column (2) are referred to Group (1) and Group (2) (countries that show cointegration between debt and GDP), while column (3) and column (4) are referred to Group (3) and Group (4) (countries that do not show cointegration). All the estimated models include the lagged GDP growth rate ($gGDP_{i,t-1}$) and the lagged debt growth rate ($gDGG_{i,t-1}$)[19], a constant ($c$), a dummy variable $Euro_{i,t}$ that captures the entrance in the monetary union, and the lagged cointegration relationship $CR_{i,t-1}$:

$$\begin{aligned} gGDP_{i,t} &= c + \gamma_1' gDGG_{i,t-1} + \beta_{11}' gGDP_{i,t-1} + \beta_{12}' Euro_{i,t} + \alpha_1' CR_{i,t-1} + u_{i,t} \\ gDGG_{i,t} &= c + \gamma_2' gGDP_{i,t-1} + \beta_{21}' gDGG_{i,t-1} + \beta_{22}' Euro_{i,t} + \alpha_2' CR_{i,t-1} + u_{i,t} \end{aligned} \tag{6}$$

which reduces to a single-equation model when one of the dependent variables is weakly exogenous.

and, in particular, integrated of order 1. This is confirmed by the results of the IPS test and the Fisher-type test for the growth rates: the null hypothesis is, in both cases, clearly rejected.

[17]Pedroni tests have been performed with and without trend; Westerlund tests have been performed with the inclusion of 2 lags, a constant, robust p-values and with and without a time trend. Westerlund tests have been repeated with a different number of lags but results have not changed much (for simplicity, these estimates are not reported).

[18]A dynamic panel model introduces endogeneity, thus Arellano-Bond estimators with robust standard errors have been used (performed by Stata 13).

[19]More lags have been added but they have not lead to any improvement.

By focussing on the first column in Table 7, all the exogenous variables are statistically significant at least at 10 percent level, but two coefficients are particularly relevant for the analysis. First, the statistically significance of the coefficient $\alpha$ of the cointegration relationship implies the tendency to converge towards the long-run relationship. Second, the negative sign of the debt growth rate implies a negative short-term relationship between the GDP growth rate and the debt growth rate. This sign was somehow expected and it reflects the negative correlations presented in Section 2.2, besides the findings of all those works that have described a negative relationship between debt and GDP. It is possible to notice that the same conclusions are also true for column (2), since both the sign of the debt growth rate in the first equation and the sign of the GDP growth rate in the second equation are negative. However, for this group, the cointegration relationship is statistically significant for the first equation only.

Columns (3) and (4) do not include $CR_{i,t-1}$ because they are based on non-cointegrated countries but, even so, results are comparable with columns (1) and (2). On the one hand, column (3) depicts a negative relationship between GDP and debt growth rates (like column (1)), though the estimated coefficient is twice as great as the previous one. On the other hand, a negative relationship arises in column (4) when the debt growth rate is the dependent variable, but not when the GDP growth rate is the dependent variable. Lastly, it can be noticed that $Euro_{i,t}$ is always significant, indicating that all groups of countries experienced a shift (with respect to before and to those countries outside the EMU) in both debt and GDP levels after the adoption of the single currency.

In summary, GDP and debt seem to converge towards their long-run relationship (when it exists), while the short-run relationship is negative in all cases except for Group (4) where, for the $gGDP_{i,t}$ case, it is not significant. Consequently, it is not possible to claim that there is a great difference in the relationship between debt and GDP among groups of countries that show a different long-run behaviour.

## 3.1 Model validity: Robustness, goodness of fit, and heterogeneity

The findings of the previous section could be affected by endogeneity, led by omitted factors bias. In order to check the validity of the previous conclusions, the following variables have been added to the basic model: inflation ($Infl_{i,t-1}$), growth rates of the general government revenues ($DRGG_{i,t-1}$), real effective exchange rate ($DREER_{i,t-1}$), long-term average bond yield ($Dr_{i,t-1}$)[20]. Results are shown in Table 8 and they do support the strength of the basic results. In fact, the sign and the significance of the cointegration relationship, of the GDP growth rate and of the debt growth rate do not change, while the magnitude of the estimated coefficients changes only slightly. Moreover, it seems that the new explanatory variables do not always improve the explanation of the dependent variables $gGDP_{i,t}$ and $gDGG_{i,t}$, though it must be underlined that the estimated coefficients have the expected sign, when significant[21].

Thus accepting to work on the basic model (6), the goodness of fit has been tested through the

[20]These variables are treated as exogenous and they have been individually studied for check stationarity. Whenever necessary, growth rates have been taken

[21]Exceptions are represented by the coefficients of $DRGG_{i,t-1}$ and $DR_{i,t-1}$ for Column (1), probably because of omitted variables or a low number of observations.

Shapiro-Wilk test for normality performed on the residuals of each model and of each country. This test has been repeated two times, one for the series of the residuals, and one for the same series without some observations referred to the 2008 crisis[22]. P-values are reported in Table 9 and they clearly confirm that the estimated models are often inadequate to capture the 2008 downfall. In fact, for the majority of countries the p-values of the Shapiro-Wilk statistics allows to reject the null hypothesis of normality, but once few observations referred to the financial crisis are removed, the same test statistics does not reject normality for the countries' majority.

Secondly, the Arellano-Bond panel test has been applied to test for the presence of first order and second order residuals serial correlation, which may bias the standard errors and affect the other statistical tests. At a significance level of 1 percent the null hypothesis of no serial correlation cannot be rejected for all groups and all orders, while at 5 percent significance level the null is rejected for the presence of second order serial correlation for Group (2) - $gGDP$ case only (see Table 10). Therefore, residuals do not seem heavily affected by serial correlation problems.

Two conclusions are possible. First, the estimated models fit quite well the empirical data for the majority of countries but they are not able to capture the whole impact of the financial crisis. The same can be noticed by looking at Figures 4, 5, 6: the cointegration relationships named $Beta1^*R1(t)$ are not able to capture the impact of the crisis, though the models on which they are based include the pertaining time breaks. Second, the differences in the specifications for the cointegration analysis and the differences in the behaviour of the residuals of the dynamic panel models fully reflect the heterogeneity of the country in the dataset: it has not been possible to determine a unique model, and the panel models do not perfectly fit every country. Therefore, even if it is possible to derive general conclusions, it is possible as well to claim that they may not apply to any country.

## 3.2 Financial crisis and austerity regime: Development of the basic model

It is undeniable that the financial crisis has represented an important change in the macroeconomic regime of many countries, a change that is fully reflected in the dynamics of both public debt and GDP and that has been followed by the widespread implementation of austerity measures. In order to account for these aspects, the basic econometric model discussed in the previous sections has been extended to incorporate the following variables:

- $Crisis_{i,t}$, a dummy equal to 1 from 2008Q3 to 2009Q4, which captures the impact of the financial crisis.
- $Austerity_{i,t}$, a dummy equal to 1 from 2010Q1 to 2015Q4. The impact of the austerity measures in Europe varies from country to country, but this temporal dummy should capture the impact of the post-crisis period, which coincides with the generalized austerity period.
- Two interaction terms between the previous dummies and the main independent variable (i.e., $gDGG_{i,t}$ and $gGDP_{i,t}$, according to the model that is being estimated).

[22] A maximum of three observations between 2008Q1 and 2009Q1 have been excluded.

The estimated models incorporating these explanatory variables are shown in Table 11. In contrast to what has arisen in Table 8, in this case the general conclusions of the basic model are not valid anymore.

In column (1) $CR_{i,t-1}$ and $Euro_{i,t}$ remain statistical significant and their sign do not change with respect to 7, but $gGDP_{i,t-1}$ is no more significant and $gDGG_{i,t-1}$ becomes positive. Since the variables $Crisis_{i,t}$, $Austerity_{i,t}$, and one of the two interaction terms are significant and negative, it is possible to say that the negative feedback of $gDGG_{i,t-1}$ on $gGDP_{i,t}$ is now incorporated by these new variables. For the first equation referred to Group (2), i.e. column (2), $Crisis_{i,t}$ and $Austerity_{i,t}$ acquire again a negative sign, but now $gDGG_{i,t-1}$ and the interaction terms are not statistical significant. In the second equation, the coefficient of $gGDP_{i,t-1}$ remains negative and significant but its magnitude is less than a half with respect to 7, and $Crisis_{i,t}$'s coefficient is significant and positive, reflecting the increase in public debts during the financial crisis. Therefore, for Group (2) $Euro_{i,t}$ and $CR_{i,t-1}$ do not change much with respect to the basic model, but the short-run relationship between debt and GDP disappears in the first equation, while it becomes considerably lower in the second equation. Moreover, in the second equation the coefficient of $Crisis_{i,t}$ correctly captures again the increment in the amount of public debts during the financial crisis, but the coefficient of $Austerity_{i,t}$ is not significant, as for the interaction terms, thus indicating that the countries in Group (2) did not experience a general reduction in public debts during that period or, otherwise, that the austerity measures were not efficient or not implemented. The same conclusions reached for Group (2) are also true for Group (3) and Group (4). It is worthwhile noting that in column (4) also the interactions term are significant, and that the sign of the $Austerity_{i,t}$'s coefficient in the $gDGG_{i,t}$ equation is positive and statistical significant, reflecting the fact that, in the austerity regime, the countries in this groups experienced a general increase in their public debts, and not a reduction.

Summing up, the inclusion of temporal dummies variables and appropriate interaction terms to account for the financial crisis and the subsequent austerity period has totally changed the conclusions reached in the previous section on the basis of model 6: the short-run relationship between public debt and GDP is no more negative (except for the second equation of column (2)), and it is now incorporated by the temporal dummies and the interaction terms, thus implying that the negative sign was due to the post-2008 events. Furthermore, the distinction between "crisis" and "austerity" allows to see that in both periods (and not only in the first one) all groups experienced a fall in their GDP growth rates and a positive (or, at least, non-significant) impact on their debt growth rates.

# 4 GDP decomposition

Although debt and GDP have been found to be cointegrated, this is not a general result since no cointegration is almost as common as cointegration in the data set. It is important to underline that all those studies analysing debt and growth by employing the GDP series do not consider the fact that GDP is an aggregate economic variables formed by many subcomponents. Therefore, the relationships linking debt and GDP could reflect themselves into the relationships between public debt and the GDP components, but it could also be the converse, i.e. the relationships between the debt components and the GDP components offset at the aggregate level. In this case, the cointegration relationships can be

considered, in a certain sense, as founded, since the econometric properties at the aggregate level are not in contrast with the properties at the disaggregate level.

For this reason the analysis has been repeated by considering exports, imports, gross fixed capital formation, public expenditure, and consumptions instead of GDP. Results are shown in Appendix B, from Table 12 to Table 16 (a synthesis is reported in Table 17), and three groups of countries have been identified:

- No cointegration at the aggregate level and no cointegration at the disaggregate level[23]: Greece, Spain, Portugal.
- Cointegration at the aggregate level and cointegration at the disaggregate level: Austria, Cyprus, France, Germany, Italy, Latvia, Lithuania, Lux, Sweden.
- No cointegration at the aggregate level and cointegration at the disaggregate level: Belgium, Bulgaria, Estonia, Finland, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, UK.

These three groups allow for considering the results of paragraph 2.3 as founded: when cointegration arises at aggregate level, it also arises for at least one subcomponent. Noteworthy is the case of Finland: cointegration arises for all subcomponents but not for the GDP, a result that may be explained by the fact that the statistical properties of the time series at the aggregate level are not equal to the properties at the disaggregate level.

# 5 Conclusions

In this work we have attempted to find out whether a long-run relationship between government debt and GDP growth exists. Then, we have described it and we have also analysed the short-run feedback that links debt and GDP. On the basis of our findings we can conclude that a long-run equilibrium relationship exists for some countries - and debt and GDP tend to adjust towards it - but it is not generalizable. Therefore, we have divided the countries in our data set according to a search for the proper econometric model to estimate, and we have exploited this strategy to compare the identified groups. Our estimations show that there is a short-run relationship between public debt and GDP (except for one sub-case) whose effect depends on some variables for the financial crisis and the austerity period, thus showing the fact that the negative relationship between debt and GDP is a consequence of exogenous events or factors. Moreover, our cointegration analysis and the panel estimates highlight the high degree of heterogeneity that characterized the countries in our dataset. In fact, a single equation describing the GDP-debt relationship and a single long-run equilibrium relationship do not seem to exist.

Subsequently, in order to support our findings, we have taken the GDP components into account and we have repeated the analysis for each of them: results clearly show that the cointegration relationship between debt and GDP are all epirically founded and they are detected into at least one component. At the same time, the majority of countries that does not show cointegration at

[23]For at least one component.

the aggregate level shows cointegration at least for one component, thus reflecting the fact that the properties of the time series at the aggregate level change with respect to the disaggregate level.

Finally, our panel cointegration analysis has highlighted the limits of the available panel cointegration tests in econometric theory and, as a consequence, has not allowed us to confirm our country-level results.

# Appendix

Table 1: Data set structure

| Country | GDP[1] | Pubic debt[2] | Seasonally adj. | EMU |
|---|---|---|---|---|
| 1. Austria | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP, Debt | 1999 |
| 2. Belgium | 1999Q1-2015Q4 | 1999Q1-2015Q4 | GDP, Debt | 1999 |
| 3. Bulgaria | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | - |
| 4. Cyprus | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 2008 |
| 5. Czech rep | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | - |
| 6. Denmark | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 1999 |
| 7. Estonia | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 2011 |
| 8. Finland | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP, Debt | 1999 |
| 9. France | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP, Debt | 1999 |
| 10. Germany | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 1999 |
| 11. Greece | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 2001 |
| 12. Hungary | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | - |
| 13. Ireland | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP, Debt | 1999 |
| 14. Italy | 1999Q1-2015Q4 | 1999Q1-2015Q4 | GDP, Debt | 1999 |
| 15. Latvia | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 2014 |
| 16. Lithuania | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP, Debt | 2015 |
| 17. Luxembourg | 2000Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 1999 |
| 18. Netherlands | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 1999 |
| 19. Portugal | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 1999 |
| 20. Romania | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | - |
| 21. Slovak rep | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 2009 |
| 22. Slovenia | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | 2007 |
| 23. Spain | 1999Q1-2015Q4 | 1999Q1-2015Q4 | GDP | 1999 |
| 24. Sweden | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP | - |
| 25. UK | 1999Q1-2015Q4 | 2000Q1-2015Q4 | GDP, Debt | - |

*Source: Eurostat.*

[1] *Gross domestic product at market prices (namq_10_gdp)*

[2] *General government consolidated gross debt (gov_10q_ggdebt)*

Table 2: Data summary and correlations

| Country | gGDP | | gDGG | | Correlation | Kendall's Tau | Spearman's Rho |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| Austria | 0,004 | 0,008 | 0,007 | 0,026 | -0,061 | -0,006 | -0,002 |
| Belgium | 0,004 | 0,007 | 0,003 | 0,011 | -0,470 | -0,138 | -0,186 |
| Bulgaria | 0,009 | 0,016 | -0,008 | 0,060 | -0,238 | -0,196 | -0,290 |
| Cyprus | 0,004 | 0,011 | 0,015 | 0,054 | -0,284 | -0,160 | -0,249 |
| Czech rep | 0,007 | 0,012 | 0,022 | 0,045 | 0,056 | 0,057 | 0,103 |
| Denmark | 0,002 | 0,009 | -0,003 | 0,058 | -0,319 | -0,015 | -0,031 |
| Estonia | 0,009 | 0,026 | 0,017 | 0,069 | -0,185 | -0,113 | -0,182 |
| Finland | 0,004 | 0,014 | 0,008 | 0,050 | -0,203 | -0,004 | -0,025 |
| France | 0,003 | 0,006 | 0,011 | 0,010 | -0,281 | -0,138 | -0,187 |
| Germany | 0,003 | 0,009 | 0,005 | 0,017 | 0,011 | -0,044 | -0,064 |
| Greece | 0,000 | 0,018 | 0,009 | 0,036 | 0,025 | -0,050 | -0,074 |
| Hungary | 0,005 | 0,011 | 0,010 | 0,043 | -0,120 | 0,060 | 0,079 |
| Ireland | 0,010 | 0,019 | 0,020 | 0,061 | -0,509 | -0,368 | -0,535 |
| Italy | 0,001 | 0,008 | 0,004 | 0,010 | -0,138 | 0,005 | 0,013 |
| Latvia | 0,009 | 0,023 | 0,026 | 0,100 | -0,299 | -0,052 | -0,069 |
| Lithuania | 0,010 | 0,029 | 0,019 | 0,055 | -0,090 | -0,041 | -0,057 |
| Luxembourg | 0,007 | 0,018 | 0,027 | 0,093 | -0,151 | 0,250 | 0,340 |
| Netherlands | 0,003 | 0,007 | 0,005 | 0,034 | -0,258 | -0,013 | -0,029 |
| Portugal | 0,001 | 0,008 | 0,015 | 0,024 | -0,152 | -0,107 | -0,151 |
| Romania | 0,008 | 0,017 | 0,020 | 0,071 | -0,342 | -0,116 | -0,184 |
| Slovak rep | 0,009 | 0,022 | 0,011 | 0,039 | -0,013 | 0,035 | 0,058 |
| Slovenia | 0,006 | 0,014 | 0,025 | 0,055 | -0,264 | -0,157 | -0,220 |
| Spain | 0,005 | 0,008 | 0,012 | 0,027 | -0,734 | -0,478 | -0,675 |
| Sweden | 0,006 | 0,012 | 0,001 | 0,036 | -0,006 | -0,026 | -0,052 |
| UK | 0,005 | 0,007 | 0,017 | 0,036 | -0,358 | -0,149 | -0,213 |

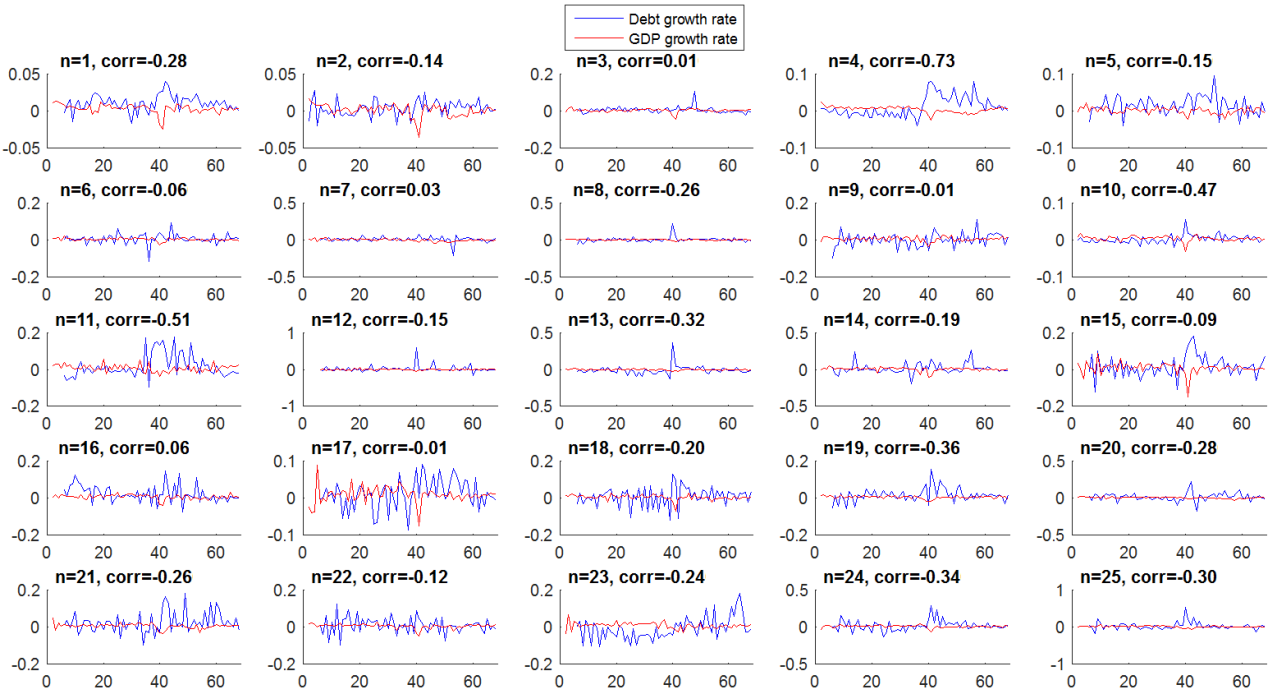



Figure 1: Debt and GDP logarithm growth rates

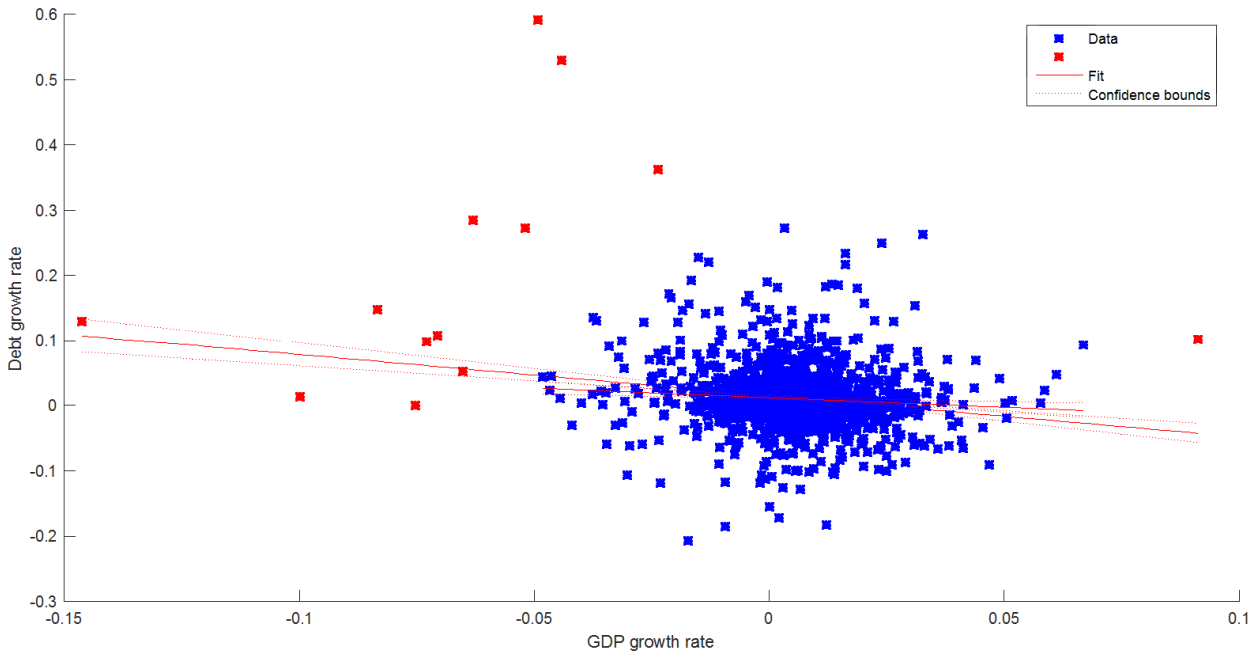



Figure 2: Debt and GDP quarterly growth rates, scatterplot with regression lines

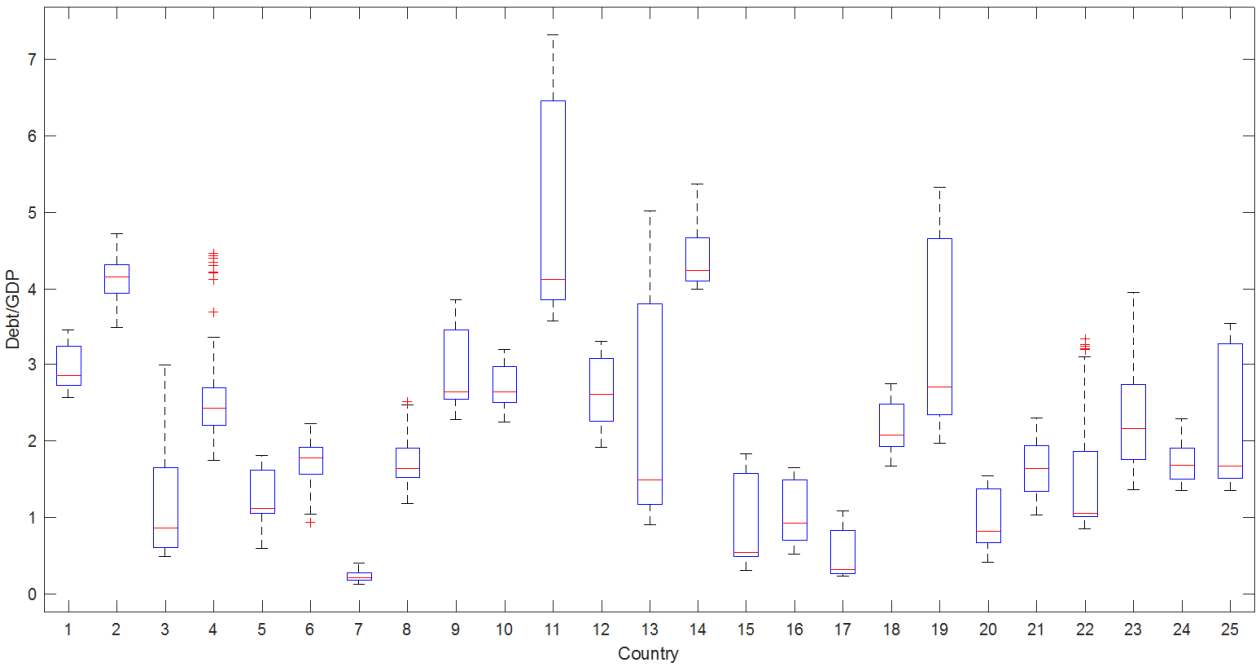



Figure 3: Quarterly debt-to-GDP ratio, boxplots by country

Table 3: Cointegration analysis: Johansen trace test with Burtlett Correction (BC), tests on residuals, and tests for weak exogeneity (p-values)

| Country | Cointegration rank | | Cointegration rank (BC) | | Residual autocorrelation | | | Normality | Weak exogeneity | | Parameters | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | r=0 | r=1 | r=0 | r=1 | LB test | LM(1) test | LM(2) test | | GDP | Debt | #Lags | Breaks | Sea. Dummies | Other dummies |
| Austria | 0 | 0.384 | 0 | 0.485 | 0.371 | 0.387 | 0.269 | 0.102 | 0.002 | 0 | 2 | 2008Q2 | No | 2007Q3 |
| Belgium | 0.323 | 0.503 | 0.406 | 0.548 | 0.207 | 0.484 | 0.112 | 0.171 | 0.007 | 0.439 | 2 | 2008Q3 | No | 2007Q3, 2008Q4 |
| Bulgaria | 0.097 | 0.316 | 0.107 | 0.32 | 0.195 | 0.446 | 0.263 | 0.16 | 0.002 | 0.389 | 1 | 2008Q4 | No | - |
| Cyprus | 0.047 | 0.442 | 0.053 | 0.447 | 0.938 | 0.93 | 0.352 | 0.05 | 0 (0.003) | 0.043 (0.091) | 1 | 2008Q2, 2013Q3 | Yes | 2009Q2, 2009Q4 |
| Czech rep | 0 | 0.008 | 0 | 0.008 | 0.02 | 0.144 | 0.581 | 0.527 | 0 | 0.105 | 1 | 2008Q4, 2013Q1 | No | - |
| Denmark | 0.004 | 0.959 | 0.012 | 0.981 | 0 | 0.941 | 0.165 | 0.947 | 0 | 0 | 3 | 2008Q3 | No | 2006Q2, 2008Q4 |
| Estonia | 0.001 | 0.003 | 0.001 | 0.003 | 0.339 | 0.203 | 0.822 | 0 | 0.043 | 0.14 | 1 | 2008Q3, 2012Q2 | No | 2007Q2, 2008Q1 |
| Finland | 0.001 | 0.016 | 0.001 | 0.028 | 0.259 | 0.687 | 0.191 | 0.105 | 0.014 | 0.353 | 2 | 2008Q3 | Yes | - |
| France | 0 | 0.069 | 0.001 | 0.088 | 0.143 | 0.952 | 0.697 | 0.069 | 0 | 0.66 | 2 | 2008Q4 | No | 2009Q1, 2009Q2 |
| Germany | 0.02 | 0.302 | 0.023 | 0.302 | 0.008 | 0.343 | 0.051 | 0.246 | 0.045 | 0.002 | 1 | 2008Q3 | No | 2009Q1, 2010Q4 |
| Greece | 0.01 | 0.029 | 0.012 | 0.03 | 0.287 | 0.483 | 0.07 | 0.746 | 0.016 | 0.212 | 1 | 2008Q3, 2011Q4 | No | 2012Q1 |
| Hungary | 0 | 0.855 | 0 | 0.871 | 0.582 | 0.329 | 0.974 | 0.613 | 0 | 0 | 2 | 2008Q4 | Yes | - |
| Ireland | 0 | 0.003 | 0.001 | 0.004 | 0.001 | 0.199 | 0.821 | 0.024 | 0.005 | 0.623 | 1 | 2008Q2, 2013Q1 | No | - |
| Italy | 0 | 0.131 | 0 | 0.133 | 0.221 | 0.754 | 0.839 | 0.354 | 0 | 0.226 (0.337) | 1 | 2008Q4, 2011Q3 | No | 2009Q1 |
| Latvia | 0 | 0.071 | 0 | 0.138 | 0.174 | 0.348 | 0.031 | 0.256 | 0.028 | 0 | 3 | 2008Q4 | No | 2008Q3 |
| Lithuania | 0.002 | 0.04 | 0.004 | 0.054 | 0.176 | 0.126 | 0.466 | 0.305 | 0.001 | 0.005 | 2 | 2008Q4, 2010Q2 | No | 2009Q1 |
| Luxembourg | 0 | 0.193 | 0 | 0.197 | 0.271 | 0.099 | 0.06 | 0.075 | 0.021 (0.049) | 0 | 1 | 2008Q4 | No | - |
| Netherlands | 0.637 | 0.807 | 0.715 | 0.874 | 0.011 | 0.356 | 0.423 | 0.574 | 0.006 | 0.257 | 2 | 2008Q2 | No | 2008Q4, 2014Q1 |
| Portugal | 0.376 | 0.524 | 0.396 | 0.524 | 0.213 | 0.703 | 0.642 | 0.388 | 0.011 | 0.526 | 1 | 2008Q3 | No | 2009Q1, 2011Q2 |
| Romania | 0 | 0.043 | 0 | 0.044 | 0.839 | 0.007 | 0.381 | 0.783 | 0 | 0 | 1 | 2008Q4 | No | (2009Q1) |
| Slovak rep | 0.161 | 0.505 | 0.175 | 0.509 | 0.686 | 0.284 | 0.435 | 0.292 | 0.001 | 0.517 | 1 | 2008Q2 | No | 2009Q1 |
| Slovenia | 0 | 0.034 | 0 | 0.035 | 0.191 | 0.662 | 0.504 | 0.053 | 0 | 0 | 1 | 2008Q2 | No | 2011Q1 |
| Spain | 0.124 | 0.395 | 0.233 | 0.529 | 0 | 0.31 | 0.397 | 0.054 | 0.033 | 0.003 | 2 | 2008Q1 | No | 2012Q4 |
| Sweden | 0 | 0.201 | 0.001 | 0.259 | 0.015 | 0.613 | 0.179 | 0.958 | 0 | 0.018 | 2 | 2008Q4 | No | 2010Q4 |
| UK | 0 | 0 | 0 | 0.001 | 0.046 | 0.081 | 0.019 | 0.564 | 0 | 0.022 | 2 | 2008Q3 | No | - |

Table 4: Unit-root tests for unbalanced panel data

| IPS unit-root test for unbalanced panels (p-value) | | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| ln(GDP) | 0 | 0,0122 | 0,1043 | 0,188 | 0,4587 |
| ln(DGG) | 0,999 | 0,999 | 0,999 | 0,999 | 0,999 |
| | | | | | |
| gGDP | 0 | 0 | 0 | 0 | 0 |
| gDGG | 0 | 0 | 0 | 0 | 0 |

| Fisher-type test (ADF - chi squared distribution) | | | | | |
|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| ln(GDP) | 0 | 0,0452 | 0,4783 | 0,5997 | 0,9351 |
| ln(DGG) | 0,999 | 0,999 | 0,999 | 0,999 | 0,999 |
| | | | | | |
| gGDP | 0 | 0 | 0 | 0 | 0 |
| gDGG | 0 | 0 | 0 | 0 | 0 |

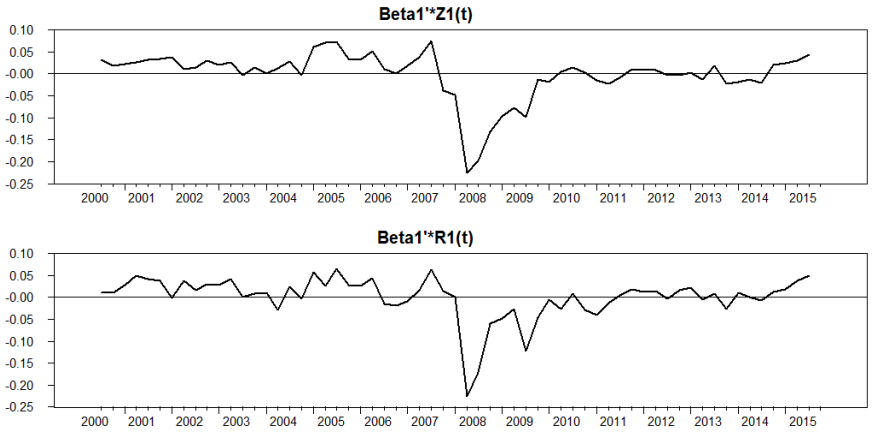
Table 5: Unit-root tests for balanced panel data

| Breitung test | |
|---|---|
| ln(GDP) | 0,9987 |
| ln(DGG) | 0,9997 |
| | |
| Harris-Tzavalis test (p-value) | |
| ln(GDP) | 1 |
| ln(DGG) | 0,9742 |

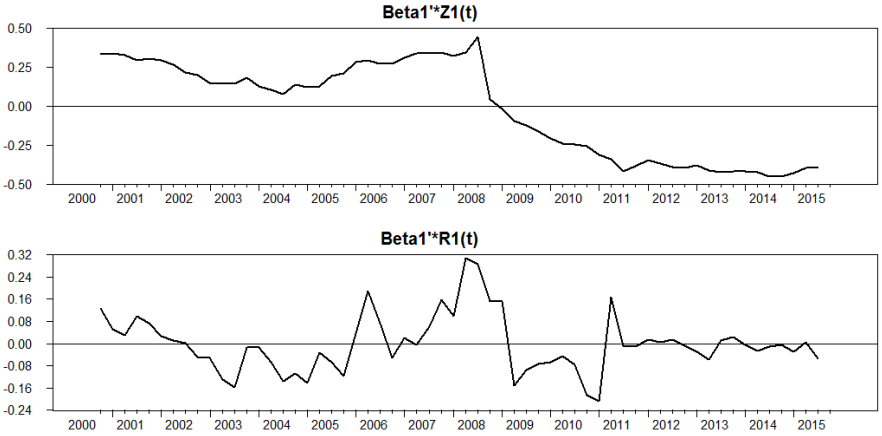
Table 6: Panel cointegration tests

| Pedroni (Test statistics) | | | | | Westerlund (Robust p-value) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Data set | | | | | Data set | | | |
| Dependent V. | DGG | DGG | GDP | DGG | Dependent V. | DGG | DGG | GDP | DGG |
| Independent V. | GDP | GDP | DGG | GDP | Independent V. | GDP | GDP | DGG | GDP |
| Trend | No | Yes | No | Yes | # Lags | 2 | 2 | 2 | 2 |
| | | | | | Constant | Yes | Yes | Yes | Yes |
| Vp | -2.423*** | -0.1596 | -2.488*** | -1.646* | Trend | No | Yes | No | Yes |
| RHOp | -2.716*** | 0.1067 | 2.52*** | 0.1522 | Bootstrap | 100 | 100 | 100 | 100 |
| Tp | 2.913*** | 0.1802 | 2.297** | 0.4463 | | | | | |
| ADFp | 2.679*** | 0.01176 | 2.821*** | 0.1602 | Gt | 0.99 | 0.66 | 0.8 | 1 |
| RHOg | 3.669*** | 0.1205 | 3.651*** | 0.156 | Ga | 1 | 0.9 | 1 | 0.96 |
| Tg | 4.062*** | -0.7092 | 3.241*** | -0.6497 | Pt | 0.78 | 0.68 | 0.38 | 1 |
| ADFg | 3.473*** | -0.2289 | 2.694*** | -0.2323 | Pa | 0.98 | 0.79 | 0.82 | 1 |
| # Countries | 25 | 25 | 25 | 25 | # Countries | 25 | 25 | 25 | 25 |
| # Obs | 1612 | 1612 | 1612 | 1612 | # Obs | 1612 | 1612 | 1612 | 1612 |
| Cointegration. Debt is weakly exogenous | | | | | Cointegration. Debt is weakly exogenous | | | | |
| Dependent V. | DGG | DGG | GDP | DGG | Dependent V. | DGG | DGG | GDP | DGG |
| Independent V. | GDP | GDP | DGG | GDP | Independent V. | GDP | GDP | DGG | GDP |
| Trend | No | Yes | No | Yes | # Lags | 2 | 2 | 2 | 2 |
| | | | | | Constant | Yes | Yes | Yes | Yes |
| Vp | -0.6699 | -0.2484 | -1135 | -0.1324 | Trend | No | Yes | No | Yes |
| RHOp | 0.983 | 0.254 | 0.1418 | 0.8476 | Bootstrap | 100 | 100 | 100 | 100 |
| Tp | 0.1173 | -0.1868 | 1.736* | 0.2309 | | | | | |
| ADFp | 0.1224 | -0.1404 | 0.5863 | 0.1362 | Gt | 0.95 | 0.45 | 0.12 | 1 |
| RHOg | 1.78* | 0.6417 | 2.233** | 0.1522 | Ga | 0.98 | 0.81 | 0.52 | 0.98 |
| Tg | 2.04*** | 0.03919 | 2.846** | 0.892 | Pt | 0.46 | 0.5 | 0.2 | 1 |
| ADFg | 2.166** | 0.1041 | 0.1024 | 0.9076 | Pa | 0.81 | 0.68 | 0.5 | 1 |
| # Countries | 3 | 3 | 3 | 3 | # Countries | 3 | 3 | 3 | 3 |
| # Obs | 196 | 196 | 196 | 196 | # Obs | 196 | 196 | 196 | 196 |
| Cointegration. No weakly exogenous variable | | | | | Cointegration. No weakly exogenous variable | | | | |
| Dependent V. | DGG | DGG | GDP | DGG | Dependent V. | DGG | DGG | GDP | DGG |
| Independent V. | GDP | GDP | DGG | GDP | Independent V. | GDP | GDP | DGG | GDP |
| Trend | No | Yes | No | Yes | # Lags | 2 | 2 | 2 | 2 |
| | | | | | Constant | Yes | Yes | Yes | Yes |
| Vp | -0.1577 | 0.08053 | -0.9209 | 0.7438 | Trend | No | Yes | No | Yes |
| RHOp | 0.1063 | 0.3478 | 0.4011 | -0.6744 | Bootstrap | 100 | 100 | 100 | 100 |
| Tp | 0.8033 | 0.3253 | -0.4725 | -0.8591 | | | | | |
| ADFp | 0.1071 | -0.3186 | -0.1163 | 0.01297 | Gt | 0.9 | 0.81 | 0.4 | 0.95 |
| RHOg | 2.045** | -0.2169 | 0.1029 | -0.3161 | Ga | 1 | 0.83 | 0.79 | 0.8 |
| Tg | 1.954* | 0.0422 | -0.02929 | -0.6161 | Pt | 0.4 | 0.87 | 0.15 | 0.99 |
| ADFg | 1.788* | -0.05187 | -1484 | 0.4376 | Pa | 0.91 | 0.92 | 0.69 | 0.98 |
| # Countries | 8 | 8 | 8 | 8 | # Countries | 8 | 8 | 8 | 8 |
| # Obs | 512 | 512 | 512 | 512 | # Obs | 512 | 512 | 512 | 512 |
| No cointegration. Debt is weakly exogenous | | | | | No cointegration. Debt is weakly exogenous | | | | |
| Dependent V. | DGG | DGG | GDP | DGG | Dependent V. | DGG | DGG | GDP | DGG |
| Independent V. | GDP | GDP | DGG | GDP | Independent V. | GDP | GDP | DGG | GDP |
| Trend | No | Yes | No | Yes | # Lags | 2 | 2 | 2 | 2 |
| | | | | | Constant | Yes | Yes | Yes | Yes |
| Vp | -0.8343 | -0.1151 | -1.807* | -0.3119 | Trend | No | Yes | No | Yes |
| RHOp | 0.1001 | 0.5572 | 1.778* | 0.1536 | Bootstrap | 100 | 100 | 100 | 100 |
| Tp | 0.8528 | 0.1358 | 2** | -0.7274 | | | | | |
| ADFp | 0.02678 | 0.4438 | 2.448*** | -0.4848 | Gt | 0.94 | 0.83 | 0.98 | 0.96 |
| RHOg | 0.1151 | 0.5616 | 2.363*** | -0.06625 | Ga | 1 | 0.97 | 1 | 0.92 |
| Tg | 0.9527 | 0.1957 | 2.748*** | -0.1092 | Pt | 0.85 | 0.55 | 0.73 | 0.99 |
| ADFg | 0.3938 | 0.3903 | 2.819*** | -0.1076 | Pa | 0.93 | 0.7 | 0.86 | 1 |
| # Countries | 10 | 10 | 10 | 10 | # Countries | 10 | 10 | 10 | 10 |
| # Obs | 644 | 644 | 644 | 644 | # Obs | 644 | 644 | 644 | 644 |
| No cointegration. No weakly exogenous variable | | | | | No cointegration. No weakly exogenous variable | | | | |
| Dependent V. | DGG | DGG | GDP | DGG | Dependent V. | DGG | DGG | GDP | DGG |
| Independent V. | GDP | GDP | DGG | GDP | Independent V. | GDP | GDP | DGG | GDP |
| Trend | No | Yes | No | Yes | # Lags | 2 | 2 | 2 | 2 |
| | | | | | Constant | Yes | Yes | Yes | Yes |
| Vp | 0.1954 | -0.2532 | -0.1043 | 0.2485 | Trend | No | Yes | No | Yes |
| RHOp | -0.2341 | -0.05041 | 0.9742 | 0.03104 | Bootstrap | 100 | 100 | 100 | 100 |
| Tp | -0.2852 | -0.2096 | 0.6781 | -0.2581 | | | | | |
| ADFp | -0.4442 | -0.08292 | 0.1041 | -0.05241 | Gt | 1 | 0.2 | 0.35 | 0.82 |
| RHOg | 0.5526 | 0.6071 | 0.1007 | 0.4268 | Ga | 1 | 0.17 | 0.95 | 0.39 |
| Tg | 0.1797 | 0.23 | 0.5752 | -0.09526 | Pt | 0.96 | 0.32 | 0.5 | 0.69 |
| ADFg | -0.3289 | 0.3884 | 0.1033 | 0.2215 | Pa | 0.97 | 0.21 | 0.79 | 0.08 |
| # Countries | 4 | 4 | 4 | 4 | # Countries | 4 | 4 | 4 | 4 |
| # Obs | 260 | 260 | 260 | 260 | # Obs | 260 | 260 | 260 | 260 |

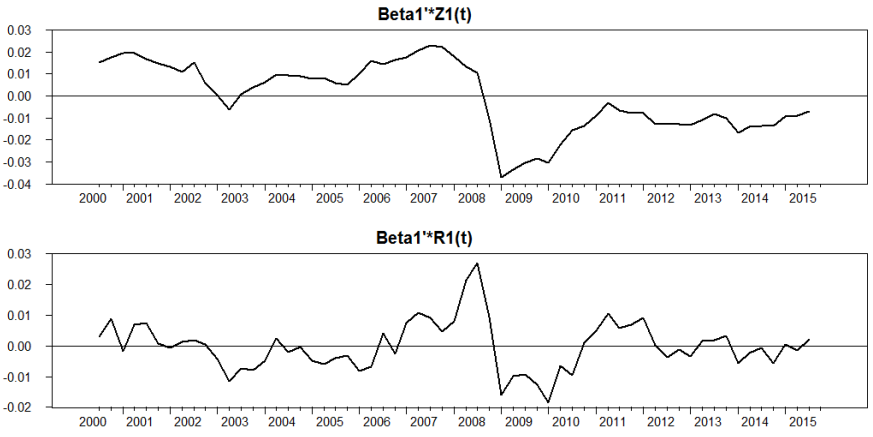
Notes: $***$, $**$ and $*$ indicate statistical significance at 1%, 5% and 10%.




Austria




Czech republic




France

Figure 4: Restricted cointegration relationships (1)

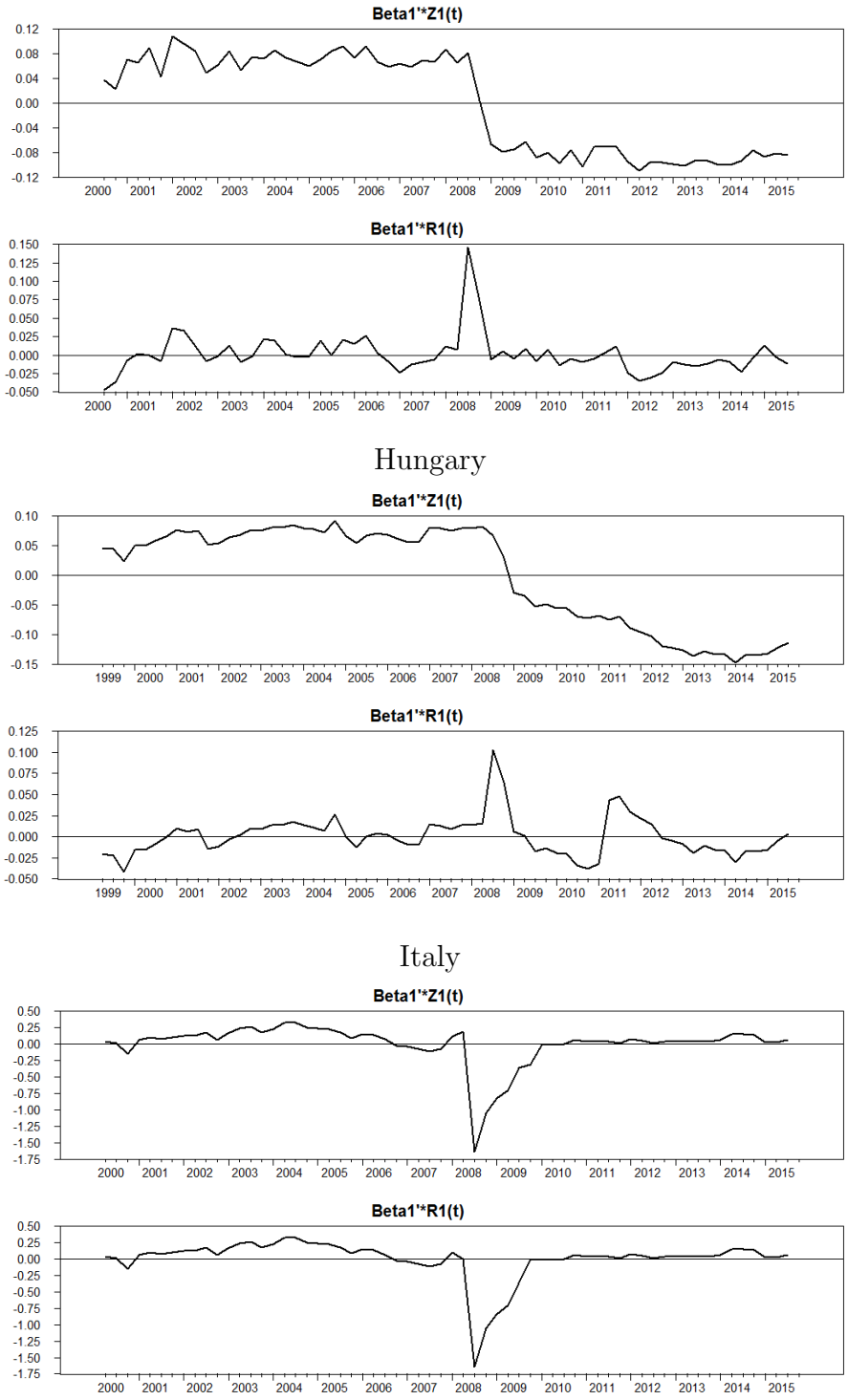
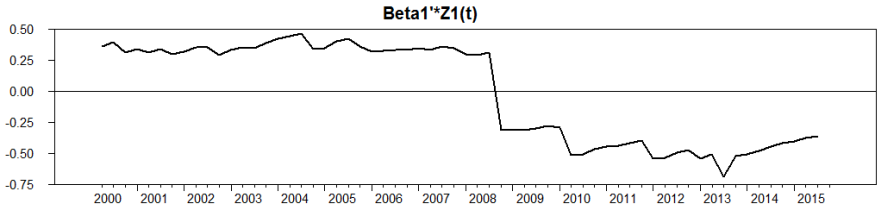
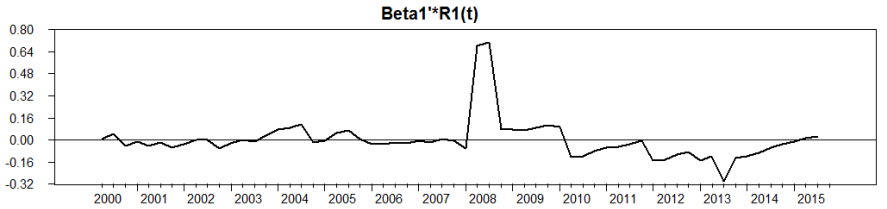
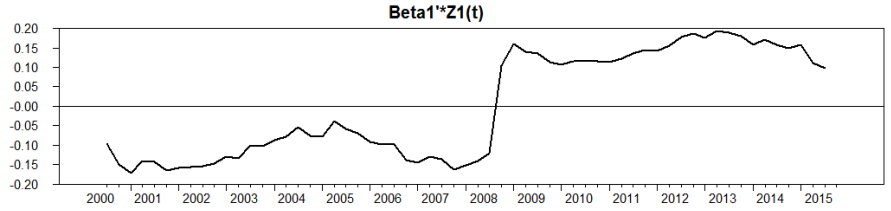


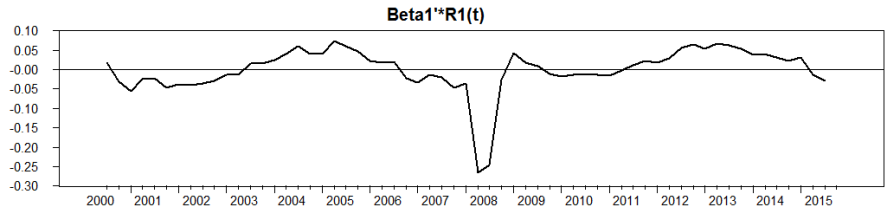

Figure 5: Restricted cointegration relationships (2)



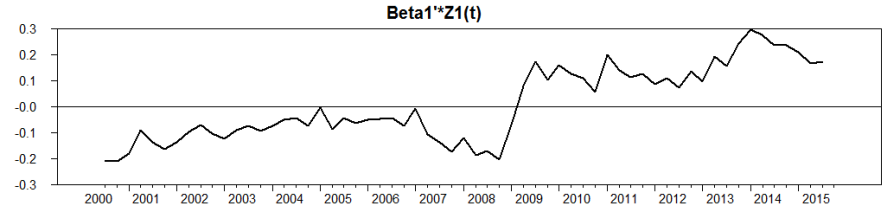



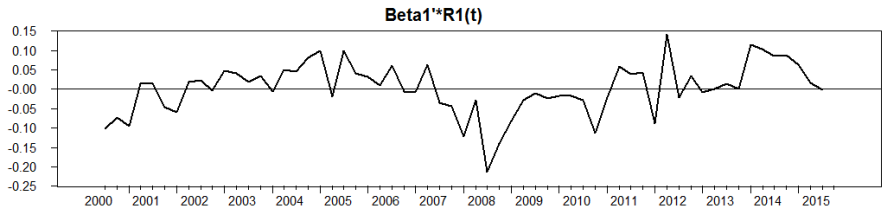

Luxembourg




Netherlands




Slovenia

Figure 6: Restricted cointegration relationships (3)

Notes: The first part of any graph, Beta*Z(t), is the equilibrium error as a function of deterministic components and short-run dynamics; the second part, Beta*R(t), depicts the clean equilibrium error corrected for the short-run dynamics. It is the second one that is tested for cointegration.

Table 7: Panel estimation: basic model

| Group | (1) | (2) | | (3) | (4) | |
|---|---|---|---|---|---|---|
| Dependent V. | gGDP | gGDP | gDGG | gGDP | gGDP | gDGG |
| gGDP(-1) | 0.2863* | 0.1048 | -1.1249*** | 0.1397* | 0.4040*** | -1.4881*** |
| | (0.1611) | (0.1003) | (0.4014) | (0.0796) | (0.0747) | (0.1254) |
| gDGG(-1) | -0.0220*** | -0.0511*** | -0.0619* | -0.0467*** | -0.0095 | -0.0561 |
| | (0.0039) | (0.0193) | (0.0357) | (0.0112) | (0.0210) | (0.0463) |
| CR(-1) | 0.0035*** | -0.0452* | 0.2666 | - | - | - |
| | (0.0013) | (0.0232) | (0.2935) | - | - | - |
| Euro | -0.0090*** | -0.0048*** | -0.0333*** | -0.0049* | -0.0053*** | 0.0113*** |
| | (0.0019) | (0.0011) | (0.0103) | (0.0028) | (0.0004) | (0.0032) |
| Const. | 0.0093*** | 0.0074*** | 0.0322*** | 0.0081*** | 0.0056*** | 0.0232*** |
| | (0.0015) | (0.0019) | (0.0100) | (0.0022) | (0.0011) | (0.0049) |
| # Countries | 3 | 8 | 8 | 10 | 4 | 4 |
| # Obs | 187 | 486 | 486 | 614 | 248 | 248 |
| Wald chi | 734.47*** | 354.88*** | 71.92*** | 77.78*** | 64.73*** | 371.41*** |

Notes: $***$, $**$ and $*$ indicate statistical significance at 1%, 5% and 10%.

Table 8: Panel estimation, alternative specifications

| Group | (1) | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|
| Dependent V. | gGDP | gGDP | gDGG | gGDP | gGDP | gGDP | gDGG |
| gGDP(-1) | 0.2792 | 0.1262 | -1.0353*** | 0.0699 | 0.1379 | 0.3819*** | -1.3372*** |
| | (0.1710) | (0.0876) | (0.3123) | (0.1087) | (0.0937) | (0.0882) | (0.2332) |
| gDGG(-1) | -0.0233*** | -0.0457*** | -0.0462 | -0.0464*** | -0.0461*** | 0.0016 | -0.0688 |
| | (0.0045) | (0.0118) | (0.0379) | (0.0151) | (0.0118) | (0.0284) | (0.0654) |
| CR(-1) | 0.0035*** | -0.0377* | 0.2735 | - | - | - | - |
| | (0.0013) | (0.0205) | (0.2789) | - | - | - | - |
| Infl(-1) | 0.1106 | -0.2390** | 0.2046 | -0.1079 | -0.0960 | 0.2102 | -0.7866* |
| | (0.1177) | (0.1183) | (1.4301) | (0.1211) | (0.0952) | (0.1568) | (0.4345) |
| DRGG(-1) | -0.0092*** | 0.0558** | -0.1485 | 0.0239 | 0.0089 | 0.0713*** | -0.3865*** |
| | (0.0036) | (0.0284) | (0.1116) | (0.0207) | (0.0196) | (0.0237) | (0.0945) |
| DREER(-1) | -0.0553 | -0.0139 | -0.2409 | 0.0629 | 0.0508 | 0.0742*** | -0.3311*** |
| | (0.0574) | (0.0427) | (0.1819) | (0.0476) | (0.0440) | (0.0261) | (0.0653) |
| Dr(-1) | 0.0041** | -0.0107** | 0.0258** | -0.0068 | - | 0.0006 | 0.0023 |
| | (0.0019) | (0.0049) | (0.0125) | (0.0055) | - | (0.0040) | (0.0182) |
| Euro | -0.0096*** | -0.0049*** | -0.0278*** | -0.0099*** | -0.0046 | -0.0059*** | 0.0148*** |
| | (0.0020) | (0.0011) | (0.0067) | (0.0029) | (0.0029) | (0.0005) | (0.0032) |
| Const. | 0.0098*** | 0.0070*** | 0.0297*** | 0.0117*** | 0.0078*** | 0.0047*** | 0.0245*** |
| | (0.0014) | (0.0016) | (0.0072) | (0.0025) | (0.0023) | (0.0011) | (0.0083) |
| # Countries | 3 | 8 | 8 | 9 | 10 | 4 | 4 |
| # Obs | 183 | 455 | 455 | 528 | 598 | 218 | 218 |
| Wald chi | 24.85*** | 2007.42*** | 2813.2*** | 983.24*** | 383.93*** | 69.35*** | 62.43*** |

Notes: $***$, $**$ and $*$ indicate statistical significance at 1%, 5% and 10%.

Table 9: Shapiro-Wilk statistics for residuals' normality

| Group 1, gGDP (p-values) | | |
|---|---|---|
| Country | Res.1 | Res.2 |
| France | 0 | 0.1069 |
| Italy | 0 | 0.1156 |
| Cyprus | 0.0194 | 0.0352 |

| Group 2, gGDP (p-values) | | | Group 2, gDGG (p-values) | | |
|---|---|---|---|---|---|
| Country | Res.1 | Res.2 | Country | Res.1 | Res.2 |
| Germany | 0 | 0.9016 | Germany | 0 | 0.5446 |
| Austria | 0.0028 | 0.2653 | Austria | 0 | 0 |
| Sweden | 0.5887 | 0.8237 | Sweden | 0.5422 | 0.3277 |
| Luxembourg | 0.8075 | 0.5388 | Luxembourg | 0 | 0 |
| Denmark | 0.1423 | 0.7894 | Denmark | 0 | 0.1449 |
| Lithuania | 0 | 0.0574 | Lithuania | 0.3755 | 0.2771 |
| Hungary | 0 | 0.0007 | Hungary | 0.8111 | 0.8761 |
| Latvia | 0.0006 | 0.1359 | Latvia | 0 | 0.2543 |

| Group 3, gGDP (p-values) | | |
|---|---|---|
| Country | Res.1 | Res.2 |
| Portugal | 0.5312 | 0.8755 |
| Greece | 0.8021 | 0.7554 |
| Netherlands | 0.3140 | 0.6829 |
| Belgium | 0 | 0.4276 |
| Ireland | 0.1142 | 0.1474 |
| Estonia | 0 | 0.0008 |
| Czech Republic | 0.0024 | 0.8856 |
| Slovakia | 0 | 0.4444 |
| Finland | 0 | 0.0264 |
| Bulgaria | 0.4077 | 0.2735 |

| Group 4, gGDP (p-values) | | | Group 4, gDGG (p-values) | | |
|---|---|---|---|---|---|
| Country | Res.1 | Res.2 | Country | Res.1 | Res.2 |
| Spain | 0.0008 | 0.3790 | Spain | 0.0265 | 0.0838 |
| UK | 0.3365 | 0.5944 | UK | 0.0173 | 0.0337 |
| Slovenia | 0.0006 | 0.0005 | Slovenia | 0.2101 | 0.1765 |
| Romania | 0.0054 | 0.5337 | Romania | 0.0185 | 0.1191 |

Notes: Res.1=Residuals of the basic models.

Res.2=Residuals of the basic models without the 2008 crisis observations.

Table 10: Arellano-Bond tests for residuals' serial correlation

| Group 1, gGDP | |
|---|---|
| Order | P-value |
| 1 | 0.1053 |
| 2 | 0.5132 |

| Group 2, gGDP | | Group 2, gDGG | |
|---|---|---|---|
| Order | P-value | Order | P-value |
| 1 | 0.0326 | 1 | 0.0233 |
| 2 | 0.0435 | 2 | 0.8854 |

| Group 3, gGDP | |
|---|---|
| Order | P-value |
| 1 | 0.0132 |
| 2 | 0.6195 |

| Group 4, gGDP | | Group 4, gDGG | |
|---|---|---|---|
| Order | P-value | Order | P-value |
| 1 | 0.0833 | 1 | 0.0964 |
| 2 | 0.932 | 2 | 0.2489 |

Table 11: Panel estimation, extended basic model: crisis and austerity

| Group | (1) | (2) | | (3) | (4) | |
|---|---|---|---|---|---|---|
| Dependent V. | gGDP | gGDP | gDGG | gGDP | gGDP | gDGG |
| gGDP(-1) | 0.1365 | -0.0723 | -0.5836** | -0.0023 | 0.2346*** | 0.0829 |
| | (0.1626) | (0.0633) | (0.2327) | (0.0782) | (0.0457) | (0.1214) |
| gDGG(-1) | 0.0098*** | -0.0408 | -0.1301*** | -0.0021 | -0.0115 | -0.1870*** |
| | (0.0023) | (0.0272) | (0.0290) | (0.0170) | (0.0077) | (0.0289) |
| CR(-1) | 0.0058*** | -0.0350* | 0.2472 | - | - | - |
| | (0.0017) | (0.0186) | (0.2723) | - | - | - |
| Euro | -0.0072*** | -0.0050*** | -0.0295*** | -0.0011 | -0.0006 | -0.0113 |
| | (0.0016) | (0.0010) | (0.0080) | (0.0020) | (0.0015) | (0.0076) |
| Crisis | -0.0092*** | -0.0258*** | 0.0365** | -0.0178*** | -0.0205*** | 0.0688*** |
| | (0.0018) | (0.0060) | (0.0166) | (0.0034) | (0.0043) | (0.0209) |
| Austerity | -0.0021*** | -0.0038*** | 0.0043 | -0.0062*** | -0.0063*** | 0.0339*** |
| | (0.0007) | (0.0014) | (0.0077) | (0.0015) | (0.0200) | (0.0095) |
| gDGG(-1)*Crisis | -0.0076 | 0.0182 | - | -0.0699 | 0.0631*** | - |
| | (0.0158) | (0.0273) | - | (0.0435) | (0.0242) | - |
| gGDP(-1)*Crisis | - | - | -0.8478 | - | - | -1.9640*** |
| | - | - | (0.5777) | - | - | (0.4532) |
| gDGG(-1)*Austerity | -0.0021*** | 0.0332 | - | -0.0301 | 0.0401** | - |
| | (0.0007) | (0.0316) | - | (0.0208) | (0.0176) | - |
| gGDP(-1)*Austerity | - | - | 0.4027 | - | - | -0.4055 |
| | - | - | (0.3265) | - | - | (0.8358) |
| Const. | 0.0097*** | 0.0121*** | 0.0210*** | 0.0104*** | 0.0082*** | 0.0050* |
| | (0.0017) | (0.0024) | (0.0094) | (0.0018) | (0.0014) | (0.0026) |
| # Countries | 3 | 8 | 8 | 10 | 4 | 4 |
| # Obs | 187 | 486 | 486 | 614 | 248 | 248 |
| Wald chi | 49.37*** | 2404.04*** | 1622.47*** | 1675.13*** | 752.22*** | 44.28*** |

Notes: $***$, $**$ and $*$ indicate statistical significance at 1%, 5% and 10%.

Table 12: Household final consumptions

| | Cointegration rank | | Cointegration rank | | Residual autocorrelation | | | Normality | Weak exogeneity | | Parameters | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | r=0 | r=1 | r=0 | r=1 | LB test | LM(1) test | LM(2) test | | DGG | CH | #Lags | Breaks | Sea. Dummies | Other Dummies |
| Austria | 0,046 | 0,3 | 0,04 | 0,296 | 0,773 | 0,563 | 0,951 | 0,064 | 0,002 | 0,049 | 1 | 2009Q3 | No | - |
| Belgium | 0 | 0,194 | 0 | 0,152 | 0,128 | 0,173 | 0,262 | 0,402 | 0 | 0,577 | 3 | 2008Q4 | No | - |
| Bulgaria | 0,004 | 0,008 | 0,003 | 0,008 | 0,565 | 0,171 | 0,689 | 0,651 | 0,027 | 0,971 | 1 | 2008Q1, 2014Q2 | No | - |
| Cyprus | 0,009 | 0,222 | 0,005 | 0,188 | 0,095 | 0,707 | 0,451 | 0,156 | 0,102 | 0 | 2 | 2008Q3, 2013Q2 | No | - |
| Czech rep | 0,015 | 0,134 | 0,008 | 0,087 | 0,019 | 0,357 | 0,178 | 0,078 | 0,001 | 0,425 | 3 | 2012Q2 | No | |
| Denmark | 0,1 | 0,739 | 0,091 | 0,735 | 0,01 | 0,115 | 0,121 | 0,551 | 0,007 | 0,001 | 1 | 2008Q3 | No | 2008Q4, 2009Q1 |
| Estonia | 0,271 | 0,397 | 0,253 | 0,392 | 0,133 | 0,865 | 0,47 | 0 | 0,014 | 0,351 | 1 | 2007Q4, 2011Q4 | No | - |
| Finland | 0,057 | 0,749 | 0,039 | 0,712 | 0,1 | 0,874 | 0,201 | 0,118 | 0,001 | 0,002 | 2 | 2008Q4 | No | - |
| France | 0,177 | 0,463 | 0,163 | 0,468 | 0,022 | 0,416 | 0,574 | 0,11 | 0,003 | 0,13 | 1 | 2008Q2 | No | - |
| Germany | 0 | 0,419 | 0 | 0,371 | 0,213 | 0,044 | 0,156 | 0,12 | 0 | 0,264 | 2 | 2010Q4 | No | - |
| Greece | 0,001 | 0,007 | 0,001 | 0,006 | 0,391 | 0,368 | 0,127 | 0,589 | 0,71 | 0,003 | 1 | 2008Q4, 2011Q4 | No | 2012Q1 |
| Hungary | 0,058 | 0,378 | 0,041 | 0,363 | 0,57 | 0,965 | 0,934 | 0,887 | 0,016 | 0,113 | 2 | 2011Q1 | No | - |
| Ireland | 0 | 0,064 | 0 | 0,002 | 0,007 | 0,108 | 0,32 | 0,208 | 0,001 | 0,001 | 1 | 2008Q1, 2013Q1 | No | 2007Q3, 2013Q3 |
| Italy | 0,546 | 0,942 | 0,527 | 0,941 | 0,011 | 0,136 | 0,165 | 0,129 | 0,002 | 0,056 | 1 | 2008Q3 | No | - |
| Latvia | 0 | 0,921 | 0 | 0,919 | 0,14 | 0,955 | 0,59 | 0,026 | 0 | 0,096 | 1 | 2008Q4 | Yes | - |
| Lithuania | 0,004 | 0,093 | 0,002 | 0,06 | 0,155 | 0,11 | 0,036 | 0,639 | 0,98 | 0 | 2 | 2008Q2, 2012Q2 | No | 2009Q3 |
| Luxembourg | 0 | 0,234 | 0 | 0,231 | 0,368 | 0,169 | 0,975 | 0,159 | 0 | 0,648 | 1 | 2008Q4 | No | - |
| Netherlands | 0,137 | 0,789 | 0,125 | 0,786 | 0,156 | 0,924 | 0,648 | 0,045 | 0,001 | 0,002 | 1 | 2009Q1 | No | 2008Q4 |
| Portugal | 0,533 | 0,804 | 0,515 | 0,802 | 0,439 | 0,71 | 0,439 | 0,065 | 0,003 | 0,057 | 1 | 2008Q4, 2013Q2 | No | - |
| Romania | 0,035 | 0,515 | 0,03 | 0,511 | 0,004 | 0,253 | 0,348 | 0,226 | 0,001 | 0,258 | 1 | 2008Q3 | No | - |
| Slovak rep | 0,032 | 0,81 | 0,027 | 0,807 | 0,121 | 0,387 | 0,296 | 0,403 | 0 | 0 | 1 | 2008Q1 | No | - |
| Slovenia | 0,001 | 0,174 | 0,001 | 0,171 | 0,058 | 0,107 | 0,534 | 0,033 | 0 | 0,617 | 1 | 2009Q1 | No | 2011Q1 |
| Spain | 0 | 0,014 | 0 | 0,014 | 0,229 | 0,167 | 0,21 | 0,017 | 0,008 | 0 | 2 | 2008Q2, 2013Q1 | No | 2012Q3 |
| Sweden | 0,858 | 0,847 | 0,817 | 0,826 | 0,366 | 0,595 | 0,438 | 0,104 | 0,053 | 0,151 | 2 | 2008Q2 | No | - |
| UK | 0 | 0,47 | 0 | 0,322 | 0,064 | 0,494 | 0,008 | 0,169 | 0 | 0,201 | 3 | 2009Q1 | No | - |

Table 13: Export

| | Cointegration rank | | Cointegration rank | | Residual autocorrelation | | | Normality | Weak exogeneity | | Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | r=0 | r=1 | r=0 | r=1 | LB test | LM(1) test | LM(2) test | | DGG | Exp | #Lags | Breaks | Type | Sea. Dummies | Other dummies |
| Austria | 0 | 0,005 | 0 | 0,003 | 0,133 | 0,263 | 0,083 | 0,308 | 0,579 | 0 | 2 | 2008Q2, 2009Q4 | trend | No | 2007Q4, 2009Q1 |
| Belgium | 0 | 0,141 | 0 | 0,122 | 0,394 | 0,212 | 0,181 | 0,095 | 0 | 0 | 3 | 2008Q4 | trend | No | 2011Q1 |
| Bulgaria | 0,036 | 0,525 | 0,019 | 0,495 | 0,607 | 0,234 | 0,594 | 0,104 | 0,022 | 0 | 2 | 2008Q3 | trend | No | - |
| Cyprus | 0,021 | 0,43 | 0,018 | 0,425 | 0,811 | 0,179 | 0,676 | 0,017 | 0,861 | 0 | 1 | 2008Q4 | trend | No | 2006Q4, 2009Q2, 2009Q4 |
| Czech rep | 0,001 | 0,231 | 0,001 | 0,234 | 0,058 | 0,56 | 0,599 | 0,154 | 0 | 0,019 | 1 | 2002Q3, 2008Q1 | trend | No | 2004Q2, 2010Q3, 2012Q1 |
| Denmark | 0,813 | 0,982 | 0,731 | 0,977 | 0,067 | 0,133 | 0,487 | 0,142 | 0,03 | 0,002 | 2 | 2008Q3 | trend | No | 2008Q4, 2009Q1 |
| Estonia | 0,893 | 0,871 | 0,849 | 0,855 | 0,012 | 0,784 | 0,915 | 0 | 0,037 | 0,135 | 2 | 2008Q3 | trend | No | - |
| Finland | 0,025 | 0,735 | 0,017 | 0,651 | 0,554 | 0,513 | 0,163 | 0,051 | 0,023 | 0 | 2 | 2008Q4 | trend | No | 2009Q4 |
| France | 0 | 0,055 | 0 | 0,053 | 0,799 | 0,122 | 0,131 | 0,125 | 0 | 0,396 | 2 | 2008Q4 | trend | No | 2009Q1, 2010Q3 |
| Germany | 0,004 | 0,31 | 0,002 | 0,249 | 0,215 | 0,731 | 0,17 | 0,024 | 0,001 | 0 | 3 | 2008Q4, 2009Q2 | trend | No | 2010Q4 |
| Greece | 0,033 | 0,585 | 0,029 | 0,581 | 0,046 | 0,337 | 0,302 | 0,066 | 0,002 | 0,002 | 1 | 2008Q4 | trend | No | 2012Q1 |
| Hungary | 0,258 | 0,923 | 0,198 | 0,908 | 0,887 | 0,127 | 0,348 | 0,268 | 0,385 | 0 | 2 | 2008Q3 | level | No | - |
| Ireland | 0 | 0,702 | 0 | 0,409 | 0,663 | 0,028 | 0,103 | 0,064 | 0 | 0,535 | 2 | 2008Q2 | trend | No | 2007Q3 |
| Italy | 0,01 | 0,544 | 0,005 | 0,477 | 0,004 | 0,366 | 0,486 | 0,453 | 0,871 | 0 | 2 | 2008Q3 | trend | No | 2009Q1 |
| Latvia | 0,001 | 0,109 | 0 | 0,059 | 0,019 | 0,241 | 0,231 | 0,146 | 0,031 | 0 | 3 | 2008Q3 2010Q1 | trend | No | 2008Q4 |
| Lithuania | 0 | 0,012 | 0 | 0,005 | 0,709 | 0,759 | 0,158 | 0,169 | 0 | 0,007 | 2 | 2008Q3 2010Q1 | trend | No | - |
| Luxembourg | 0 | 0,621 | 0 | 617 | 0 | 0,001 | 0,319 | 0,225 | 0 | 0 | 1 | 2008Q4 | trend | No | 2010Q2, 2013Q3 |
| Netherlands | 0 | 0 | 0 | 0 | 0,042 | 0,363 | 0,298 | 0,103 | 0 | 0,003 | 3 | 2008Q2, 2009Q1 | trend | No | 2008Q3 |
| Portugal | 0,184 | 0,329 | 0,169 | 0,325 | 0,078 | 0,192 | 0,201 | 0,035 | 0,378 | 0,008 | 1 | 2008Q3 | trend | No | 2009Q1, 2011Q2 |
| Romania | 0,004 | 0,015 | 0,004 | 0,014 | 0,022 | 0,285 | 0,672 | 0,466 | 0,39 | 0,007 | 1 | 2008Q3, 2010Q1 | trend | No | - |
| Slovak rep | 0,115 | 0,292 | 0,104 | 0,288 | 0,098 | 0,934 | 0,649 | 0,098 | 0,114 | 0,019 | 1 | 2008Q3 | trend | No | 2009Q1 |
| Slovenia | 0,034 | 0,067 | 0,02 | 0,055 | 0,079 | 0,17 | 0,872 | 0,106 | 0,254 | 0,052 | 2 | 2008Q4 | trend | No | 2009Q1 |
| Spain | 0 | 0,019 | 0 | 0,011 | 0,102 | 0,197 | 0,2 | 0,004 | 0 | 0 | 2 | 2008Q4 | trend | No | 2007Q4, 2008Q3 |
| Sweden | 0,13 | 0,202 | 0,119 | 0,199 | 0,559 | 0,144 | 0,95 | 0,971 | 0,055 | 0,313 | 1 | 2008Q2 | trend | No | - |
| UK | 0,001 | 0,018 | 0,001 | 0,011 | 0,148 | 0,001 | 0,349 | 0,021 | 0,955 | 0,008 | 2 | 2008Q4 | trend | No | 2006Q1, 2006Q3 |

Table 14: Gross fixed capital formation

| | Cointegration rank | | Cointegration rank | | Residual autocorrelation | | | Normality | Weak exogeneity | | Parameters | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | r=0 | r=1 | r=0 | r=1 | LB test | LM(1) test | LM(2) test | | DGG | GFCF | #Lags | Breaks | Sea. Dummies | Other dummies |
| Austria | 0,419 | 0,578 | 0,398 | 0,574 | 0,646 | 0,603 | 0,901 | 0,108 | 0,071 | 0,028 | 1 | 2008Q3 | No | 2007Q4 |
| Belgium | 0,196 | 0,828 | 0,16 | 0,815 | 0,976 | 0,178 | 0,255 | 0,815 | 0 | 0,114 | 2 | 2008Q2, 2010Q3 | No | - |
| Bulgaria | 0,039 | 0,113 | 0,035 | 0,111 | 0,959 | 0,612 | 0,917 | 0,559 | 0,324 | 0,015 | 1 | 2008Q2 | No | 2010Q1 |
| Cyprus | 0,003 | 0,276 | 0,002 | 0,265 | 0,701 | 0,868 | 0,276 | 0,541 | 0,135 | 0 | 2 | 2009Q1, 2014Q1 | No | 2009Q2, 2009Q4 |
| Czech rep | 0 | 0,074 | 0 | 0,044 | 0 | 0,871 | 0,236 | 0,054 | 0,721 | 0 | 2 | 2008Q3 | No | 2013Q3, 2012Q1 |
| Denmark | 0,032 | 0,172 | 0,028 | 0,178 | 0 | 0,684 | 0,831 | 0,437 | 0,048 | 0,005 | 1 | 2008Q2, 2010Q2 | No | 2008Q3, 2008Q4 |
| Estonia | 0,469 | 0,56 | 0,374 | 0,487 | 0,144 | 0,205 | 0,96 | 0,002 | 0,716 | 0,011 | 2 | 2008Q2 | No | - |
| Finland | 0,042 | 0,365 | 0,027 | 0,282 | 0,618 | 0,243 | 0,171 | 0,124 | 0,002 | 0,06 | 2 | 2008Q2 | No | 2008Q3, 2008Q4 |
| France | 0,39 | 0,718 | 0,246 | 0,627 | 0,067 | 0,143 | 0,802 | 0,416 | 0,007 | 0,022 | 2 | 2008Q1 | No | 2008Q4 |
| Germany | 0,15 | 0,556 | 0,117 | 0,5 | 0,337 | 0,77 | 0,436 | 0,146 | 0 | 0,009 | 2 | 2013Q1 | No | 2009Q1, 2010Q4 |
| Greece | 0,348 | 0,804 | 0,291 | 0,691 | 0,154 | 0,28 | 0,41 | 0,078 | 0 | 0,961 | 2 | 2008Q4 | No | 2012Q1 |
| Hungary | 0,026 | 0,148 | 0,019 | 0,133 | 0,539 | 0,613 | 0,765 | 0,226 | 0,028 | 0,041 | 2 | 2008Q3, 2010Q3 | No | - |
| Ireland | 0 | 0,215 | 0 | 0,012 | 0,021 | 0,066 | 0,07 | 0,342 | 0 | 0,191 | 2 | 2008Q1 | No | 2007Q3, 2012Q2 |
| Italy | 0,055 | 0,316 | 0,049 | 0,311 | 0,385 | 0,647 | 0,994 | 0,788 | 0,038 | 0,006 | 1 | 2008Q3 | No | - |
| Latvia | 0,006 | 0,01 | 0,002 | 0,006 | 0,002 | 0,28 | 0,66 | 0,483 | 0,013 | 0,046 | 4 | 2008Q3, 2010Q1 | No | - |
| Lithuania | 0,001 | 0,004 | 0 | 0,003 | 0,9 | 0,11 | 0,927 | 0,501 | 0,286 | 0,002 | 2 | 2008Q4, 2010Q1 | No | - |
| Luxembourg | 0 | 0,05 | 0 | 0,049 | 0,203 | 0,147 | 0,234 | 0,079 | 0 | 0,035 | 1 | 2008Q4 | No | - |
| Netherlands | 0,124 | 0,435 | 0,114 | 0,43 | 0,272 | 0,213 | 0,118 | 0,043 | 0 | 0,177 | 1 | 2008Q3, 2013Q2 | No | 2008Q4, 2011Q1 |
| Portugal | 0,363 | 0,871 | 0,308 | 0,84 | 0,002 | 0,468 | 0,644 | 0,751 | 0,002 | 0,047 | 2 | 2008Q3, 2013Q2 | No | |
| Romania | 0,001 | 0,981 | 0 | 0,974 | 0,845 | 0,001 | 0,36 | 0,797 | 0 | 0,001 | 2 | 2008Q3 | No | 2007Q1 |
| Slovak rep | 0,42 | 0,706 | 0,4 | 0,703 | 0,223 | 0,606 | 0,67 | 0 | 0,694 | 0,002 | 1 | 2008Q2 | No | - |
| Slovenia | 0,001 | 0,097 | 0 | 0,095 | 0,001 | 0,155 | 0,286 | 0,173 | 0,145 | 0 | 1 | 2008Q3 | Yes | - |
| Spain | 0 | 0,009 | 0 | 0,005 | 0,03 | 0,69 | 0,222 | 0,31 | 0,645 | 0 | 2 | 2008Q1, 2013Q2 | No | 2009Q2 |
| Sweden | 0,038 | 0,39 | 0,024 | 0,301 | 0,217 | 0,612 | 0,92 | 0,164 | 0,431 | 0 | 2 | 2008Q4 | No | - |
| UK | 0,023 | 0,252 | 0,015 | 0,204 | 0,028 | 0,105 | 0,44 | 0,293 | 0,004 | 0,039 | 2 | 2008Q1 2012Q1 | No | - |

Table 15: General government final consumptions

| | Cointegration rank | | Cointegration rank | | Residual autocorrelation | | | Normality | Weak exogeneity | | Parameters | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | r=0 | r=1 | r=0 | r=1 | LB test | LM(1) test | LM(2) test | | DGG | CGG | #Lags | Breaks | Type | Sea. Dummies | Other Dummies |
| Austria | 0,002 | 0,117 | 0,001 | 0,104 | 0,293 | 0,884 | 0,786 | 0 | 0 | 0,589 | 2 | 2009Q3 | Level | No | - |
| Belgium | 0 | 0,256 | 0 | 0,252 | 0,118 | 0,23 | 0,196 | 0,313 | 0 | 0,211 | 1 | 2008Q4 | Trend | No | - |
| Bulgaria | 0,044 | 0,509 | 0,038 | 0,505 | 0,002 | 0,955 | 0,151 | 0,256 | 0,613 | 0 | 1 | 2009Q2 | Trend | No | 2009Q4 |
| Cyprus | 0,005 | 0,521 | 0,004 | 0,518 | 0,614 | 0,558 | 0,113 | 0 | 0,483 | 0 | 1 | 2011Q3 | Trend | No | 2009Q4 |
| Czech rep | 0,004 | 0,054 | 0,002 | 0,006 | 0,118 | 0,189 | 0,381 | 0,551 | 0,014 | 0,373 | 2 | 2009Q1, 2013Q2 | Trend | No | - |
| Denmark | 0 | 0,819 | 0,005 | 0,73 | 0,043 | 0,778 | 0,581 | 0,761 | 0,021 | 0 | 2 | 2008Q2 | Trend | No | 2008Q3, 2008Q4 |
| Estonia | 0,005 | 0,034 | 0,004 | 0,033 | 0,055 | 0,199 | 0,757 | 0,654 | 0,008 | 0,063 | 1 | 2008Q4, 2011Q4 | Trend | No | 2002Q2, 2007Q2, 2012Q3 |
| Finland | 0,029 | 0,55 | 0,1 | 0,509 | 0,071 | 0,55 | 0,018 | 0,582 | 0 | 0,028 | 4 | 2008Q3 | Trend | No | - |
| France | 0,017 | 0,617 | 0,008 | 0,519 | 0,101 | 0,535 | 0,834 | 0,125 | 0 | 0,611 | 2 | 2008Q3 | Trend | No | - |
| Germany | 0,519 | 0,784 | 0,5 | 0,782 | 0,003 | 0,273 | 0,134 | 0,806 | 0,002 | 0,339 | 1 | 2010Q3 | Trend | No | 2010Q4 |
| Greece | 0 | 0,004 | 0 | 0,004 | 0,151 | 0,197 | 0,316 | 0,055 | 0 | 0,002 | 1 | 2009Q2, 2012Q1 | Trend | No | - |
| Hungary | 0,071 | 0,201 | 0,046 | 0,169 | 0,108 | 0,184 | 0,018 | 0,955 | 0,004 | 0,372 | 3 | 2008Q3 | Trend | No | 2006Q1 |
| Ireland | 0,004 | 0,317 | 0,001 | 0,251 | 0,001 | 0,25 | 0,373 | 0,204 | 0 | 0,01 | 3 | 2008Q1, 2013Q1 | Trend | No | 2007Q3, 2010Q1 |
| Italy | 0,598 | 0,778 | 0,551 | 0,741 | 0,357 | 0,325 | 0,515 | 0,202 | 0,253 | 0,005 | 2 | 2008Q2 | Trend | No | - |
| Latvia | 0 | 0,062 | 0 | 0,033 | 0,005 | 0,454 | 0,288 | 0,057 | 0,731 | 0 | 2 | 2008Q2, 2010Q1 | Trend | No | 2008Q4, 2012Q1 |
| Lithuania | 0 | 0,004 | 0 | 0,004 | 0,227 | 0,058 | 0,663 | 0,07 | 0,802 | 0 | 1 | 2008Q4, 2012Q3 | Trend | No | - |
| Luxembourg | 0 | 0,109 | 0 | 0,106 | 0,016 | 0,654 | 0,637 | 0,082 | 0 | 0,499 | 1 | 2008Q4 | Trend | No | - |
| Netherlands | 0 | 0,937 | 0 | 0,93 | 0,253 | 0 | 0,782 | 0,054 | 0 | 0,017 | 2 | 2008Q4 | Trend | No | 2006Q1 |
| Portugal | 0 | 0,007 | 0 | 0,007 | 0,743 | 0,41 | 0,004 | 0,16 | 0,001 | 0 | 1 | 2009Q4, 2012Q2 | Trend | No | - |
| Romania | 0 | 0,097 | 0 | 0,095 | 0,005 | 0,172 | 0,784 | 0,141 | 0,574 | 0 | 1 | 2008Q3, 2010Q3 | Trend | No | 2007Q3 |
| Slovak rep | 0,047 | 0,422 | 0,042 | 0,418 | 0,02 | 0,954 | 0,865 | 0,177 | 0,413 | 0 | 1 | 2008Q3 | Trend | No | 2004Q1 |
| Slovenia | 0,067 | 0,8 | 0,6 | 0,797 | 0,16 | 0,348 | 0,193 | 0,142 | 0 | 0,041 | 1 | 2009Q1 | Trend | No | - |
| Spain | 0 | 0,011 | 0 | 0,005 | 0,133 | 0,084 | 0,734 | 0,955 | 0,011 | 0,002 | 2 | 2008Q2 | Trend | No | 2012Q4 |
| Sweden | 0,232 | 0,498 | 0,188 | 0,45 | 0,593 | 0,104 | 0,955 | 0,548 | 0,879 | 0,002 | 2 | 2008Q4 | Trend | No | - |
| UK | 0 | 0,015 | 0 | 0,005 | 0,052 | 0,155 | 0,21 | 0,102 | 0 | 0,211 | 3 | 2009Q1 | Trend | No | - |

Table 16: Imports

| | Cointegration rank | | Cointegration rank | | Residual autocorrelation | | | Normality | Weak exogeneity | | Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | r=0 | r=1 | r=0 | r=1 | LB test | LM(1) test | LM(2) test | | DGG | IMP | #Lags | Breaks | Type | Sea. Dummies | Other Dummies |
| Austria | 0.007 | 0.772 | 0.006 | 0.769 | 0.942 | 0.156 | 0.767 | 0 | 0.002 | 0 | 1 | 2008Q4 | Trend | No | / |
| Belgium | 0 | 0.19 | 0 | 0.1451 | 0.079 | 0.258 | 0.081 | 0.744 | 0 | 0 | 2 | 2008Q4 | Trend | No | / |
| Bulgaria | 0.008 | 0.525 | 0.007 | 0.521 | 0.069 | 0.765 | 0.466 | 0.329 | 0.044 | 0 | 1 | 2008Q4 | Trend | No | / |
| Cyprus | 0.022 | 0.522 | 0.019 | 0.517 | 0.708 | 0.97 | 0.842 | 0.297 | 0 | 0.042 | 1 | 2008Q3 | Trend | No | / |
| Czech rep | 0.23 | 0.406 | 0.214 | 0.401 | 0.076 | 0.091 | 0.16 | 0 | 0.005 | 0.767 | 1 | 2008Q3 | Trend | No | / |
| Denmark | 0 | 0.146 | 0 | 0.068 | 0.008 | 0.004 | 0.011 | 0.398 | 0 | 0.065 | 3 | 2008Q4 | Trend | No | / |
| Estonia | 0.804 | 0.816 | 0.738 | 0.794 | 0.106 | 0.125 | 0.845 | 0 | 0.047 | 0.061 | 2 | 2008Q3 | Trend | No | / |
| Finland | 0.004 | 0.106 | 0.002 | 0.067 | 0.473 | 0.655 | 0.419 | 0.031 | 0 | 0.07 | 2 | 2008Q4 | Trend | Yes | / |
| France | 0.002 | 0.176 | 0.002 | 0.173 | 0.258 | 0.314 | 0.024 | 0.011 | 0.583 | 0 | 1 | 2008Q3 | Trend | No | / |
| Germany | 0 | 0 | 0 | 0 | 0.04 | 0.482 | 0.609 | 0.008 | 0 | 0.707 | 1 | 2008Q4, 2010Q4 | Trend | No | / |
| Greece | 0 | 0.016 | 0 | 0.016 | 0.001 | 0.01 | 0.258 | 0.066 | 0 | 0.071 | 1 | 2008Q3, 2012Q1 | Trend | No | 2015Q3 |
| Hungary | 0.008 | 0.141 | 0.004 | 0.115 | 0.574 | 0.018 | 0.007 | 0.119 | 0.079 | 0.006 | 2 | 2008Q4 | Trend | No | / |
| Ireland | 0 | 0 | 0 | 0 | 0.111 | 0.399 | 0.199 | 0 | 0.222 | 0.079 | 1 | 2008Q3, 2010Q1 | Trend | No | 2010Q2 |
| Italy | 0.019 | 0.436 | 0.008 | 0.407 | 0.111 | 0.132 | 0.539 | 0.095 | 0.681 | 0 | 2 | 2008Q3 | Trend | No | / |
| Latvia | 0.001 | 0.269 | 0 | 0.181 | 0.378 | 0.163 | 0.198 | 0.009 | 0.005 | 0 | 3 | 2008Q3 | Trend | No | 2002Q1, 2008Q4 |
| Lithuania | 0 | 0.121 | 0 | 0.068 | 0.093 | 0.015 | 0.756 | 0.652 | 0 | 0.001 | 2 | 2008Q3 | Trend | No | 2009Q1 |
| Luxembourg | 0.801 | 0.797 | 0.748 | 0.762 | 0.017 | 0.414 | 0.502 | 0 | 0.026 | 0.829 | 2 | 2009Q1 | Trend | No | / |
| Netherlands | 0.176 | 0.931 | 0.115 | 0.912 | 0.038 | 0 | 0.234 | 0.433 | 0.689 | 0 | 2 | 2008Q3 | Trend | No | 2000Q4, 2008Q4 |
| Portugal | 0 | 0.088 | 0 | 0.086 | 0.166 | 0.077 | 0.065 | 0.65 | 0 | 0.555 | 1 | 2008Q3, 2011Q2 | Trend | No | 2009Q1 |
| Romania | 0 | 0.013 | 0 | 0.013 | 0.712 | 0.003 | 0.941 | 0.775 | 0.01 | 0 | 1 | 2008Q4 | Trend | No | / |
| Slovak rep | 0.33 | 0.878 | 0.311 | 0.876 | 0.307 | 0.087 | 0.797 | 0.334 | 0.024 | 0.02 | 1 | 2008Q3 | Trend | No | / |
| Slovenia | 0.019 | 0.075 | 0.011 | 0.057 | 0.142 | 0.135 | 0.846 | 0.056 | 0.525 | 0.01 | 2 | 2008Q4 | Trend | No | 2009Q1 |
| Spain | 0 | 0.004 | 0 | 0.002 | 0.008 | 0.231 | 0.322 | 0.12 | 0.068 | 0.041 | 2 | 2008Q4 | Trend | No | 2009Q1, 2012Q4 |
| Sweden | 0.156 | 0.46 | 0.092 | 0.411 | 0.254 | 0.172 | 0.784 | 0.776 | 0.014 | 0.018 | 2 | 2008Q4 | Trend | No | / |
| UK | 0 | 0.053 | 0 | 0.021 | 0.074 | 0.153 | 0.103 | 0 | 0 | 0.788 | 2 | 2008Q3 | Trend | No | 2008Q4 |

Table 17: GDP components and public debt, synthesis of the cointegration analysis

| | GDP | EXP | GFCF | CH | CGG | IMP |
|---|---|---|---|---|---|---|
| Austria | C | C | NC | C | C | C |
| Belgium | NC | C | NC | C | C | C |
| Bulgaria | NC | C | C | NC | C | C |
| Cyprus | C | C | C | C | C | C |
| Czech rep | NC | NC | C | C | C | NC |
| Denmark | C | NC | C | NC | C | C |
| Estonia | NC | C | NC | NC | NC | NC |
| Finland | NC | C | C | C | C | C |
| France | C | C | NC | NC | C | C |
| Germany | C | C | NC | C | NC | NC |
| Greece | NC | NC | NC | NC | NC | NC |
| Hungary | C | C | C | C | C | C |
| Ireland | NC | C | C | C | C | NC |
| Italy | C | C | NC | NC | NC | C |
| Latvia | C | NC | NC | C | C | C |
| Lithuania | C | C | NC | C | NC | C |
| Luxembourg | C | NC | NC | C | C | NC |
| Netherlands | NC | NC | NC | C | C | NC |
| Portugal | NC | NC | NC | NC | NC | C |
| Romania | NC | NC | NC | C | C | NC |
| Slovak rep | NC | C | NC | C | C | NC |
| Slovenia | NC | NC | C | C | NC | C |
| Spain | NC | NC | NC | NC | NC | NC |
| Sweden | C | NC | C | NC | NC | NC |
| UK | NC | NC | C | C | NC | C |
| Tot. | 11 | 13/25 | 10/25 | 16/25 | 15/25 | 14/25 |

Notes: C=Cointegration, NC=No cointegration.
EXP=Export, GFCF=Gross fixed capital formation, CH=Household final consumptions, CGG=General government final consumptions, IMP=Imports.

# References


[1] Afonso, A., Jalles, J.T. (2013). Growth and productivity: The role of government debt. International Review of Economics and Finance, 25, 384-407.

[2] Baum, A., Checherita-Wetphal, C., Rother, P. (2012). Debt and growth: New evidence for the euro area. Journal of International Money and Finance, 32, 809-821.

[3] Balassone, F., Francese, M., Pace, A. (2011). Public debt and economic growth in Italy. Quaderni Di Storia Economica, 11.

[4] Bordo, M.D., Meissner, C.M., Stuckler, D. (2010). Foreign currency debt, financial crises and economic growth: A long-run view. Journal of International Money and Finance, 29(4), 642-665.

[5] Breitung, J., Pesaran, M. H. (2005). Unit roots and cointegration in panels.

[6] Caner, M., Grennes, T. J., Kohler-Geib, F. F. N. (2010). Finding the tipping point-when sovereign debt turns bad.

[7] Cecchetti, S., Mohanty, M., Zampolli, F. (2012). Achieving Growth Amid Fiscal Imbalances: The real effects of debt in Achieving maximum long-run growth. A symposium sponsored by The Federal Reserve Bank of Kansas City. Federal Reserve Bank of Kansas City.

[8] Ceh Casni, A., Badurina, A.A., Sertic, M.B. (2014). Public debt and growth: evidence from Central, Eastern and Southeastern European countries Zb. rad. Ekon. fak. Rij. vol. 32, sv. 1, 35-51.

[9] Checherita-Westphal, C. D., Hughes Hallett, A. J., Rother, P. (2012). Fiscal sustainability using growth-maximising debt targets.

[10] Checherita-Westpahl C., Rother P. (2012). The impact of high government debt on economic growth and its channels: An empirical investigation for the euro area. European Economic Review, 56(7), 1392-1405.

[11] Cordella, T., Ricci, L. A., Ruiz-Arranz, M. (2010). Debt overhang or debt irrelevance?. IMF Staff Papers, 57(1), 1-24.

[12] Chudik, A., Mohaddes, K., Pesaran, M. H., Raissi, M. (2015). Is there a debt-threshold effect on output growth?. Review of Economics and Statistics, (0).

[13] Demetrescu, M., Hanck, C., Tarcolea, A. I. (2014). IV-Based Cointegration Testing in Dependent Panels with Time-Varying Variance. Journal of Time Series Analysis, 35(5), 393-406.

[14] Dennis, J. G. (2006). CATS in RATS: Cointegration analysis of time series. Estima.

[15] Deshpande, A. (1997). The debt overhang and the disincentive to invest, Journal of Development Economics Volume 52, Issue 1, 169-187.

[16] Eberhardt, M., Presbitero, A.F. (2015). Public debt and growth: Heterogeneity and non-linearity. Journal of International Economics, 97, 45-58.

[17] Egert, B. (2015). Public debt, economic growth and nonlinear effects: myth or reality?. Journal of Macroeconomics, 43, 226-238.

[18] Herndon, T., Ash, M., Pollin, R. (2013). Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff. Amherst, MA: Political Economy Research Institute, University of Massachusetts Amherst Working Paper No. 322.

[19] Irons, J., Bivens, J. (2010). Government Debt and Economic Growth. Epi briefing paper, 2010, 271.

[20] Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica: Journal of the Econometric Society, 1551-1580.

[21] Johansen, S., Mosconi, R., Nielsen, B. (2000). Cointegration analysis in the presence of structural breaks in the deterministic trend. The Econometrics Journal, 3(2), 216-249.

[22] Krugman, P. (1988). Financing vs. forgiving a debt overhang. Journal of development Economics, 29(3), 253-268.

[23] Lof, M., Malinen, T. (2014). Does sovereign debt weaken economic growth? A panel VAR analysis. Economics Letters 122, 403-407.

[24] Minea, A., Parent, A. (2012). Is high public debt always harmful to economic growth. Reinhart and Rogoff and Some Complex Nonlinearities. Association Franaise de Cliomtrie (AFC) Working Paper, 12-08.

[25] Nguyen, T. Q., Clements, M. B. J., Bhattacharya, M. R. (2003). External debt, public investment, and growth in low-income countries (No. 3-249). International Monetary Fund.

[26] Panizza, U., Presbitero, A. F. (2014). Public debt and economic growth: is there a causal effect?. Journal of Macroeconomics, 41, 21-41.

[27] Pattillo, C., Poirson, H., Ricci, L. A. (2011). External debt and growth. Review of Economics and Institutions, 2(3), 30.

[28] Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxford Bulletin of Economics and statistics, 61(s 1), 653-670.

[29] Presbitero, A.F. (2012). Total Public Debt and Growth in Developing Countries. European Journal of Development Research, 24(4), 606-626.

[30] Reinhart, C.M., Rogoff, K.S. (2010). Growth in Time of Debt. American Economic Review: Papers and Proceedings 100, 573-578.

[31] Westerlund, J. Persyn, D. (2008). Error-correction-based cointegration tests for panel data. Stata Journal, 8(2), 232-241.

[32] Woo, J., Kumar, M. S. (2015). Public debt and growth. Economica, 82(328), 705-739.