"Short-run and long-run effects of public debt on economic performance: Evidence from EMU countries"

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Abstract

This paper contributes to the literature by examining the possible influence of public debt on economic performance, using data from both central and peripheral countries of the European Economic and Monetary Union for the 1960-2012 period. To this end, a simple aggregate production function augmented for public debt is estimated using the ARDL bounds testing approach. Our findings tend to support the view that the level of public debt always has a negative impact on the long-run performance of EMU countries, whilst its short-run effect may be positive in some specific cases.

JEL classification: C22, F33, H63, O40, O52
Keywords: Public debt, economic growth, bounds testing, euro area, peripheral EMU countries, central EMU countries

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Acknowledgements

This paper is based upon work supported by the Government of Spain and FEDER under grant number ECO2011-23189 and ECO2013-48326. Marta Gómez-Puig also thanks the Instituto de Estudios Fiscales for financial support (project IEF 101/2014). Simón Sosvilla-Rivero thanks the Universitat de Barcelona & RFA-IREA for their hospitality. Responsibility for any remaining errors rests with the authors.

1. Introduction

This paper focuses on the effects of public debt on the economic performance of EMU countries during the period 1960 to 2012. This challenging avenue of research has been studied by economists for a long time, but has recently undergone a notable revival fuelled by the substantial deterioration of public finances in many economies as a result of the financial and economic crisis of 2008-2009[1].

In particular, in the European context, the recent global recession and sovereign debt crisis has highlighted the importance of certain academic questions that policy makers may need to answer. The events of the last few years have increased the concern about the possible adverse consequences of the accumulation of public debt in EMU countries[2]. The debate is hotly contested, because pundits draw widely different conclusions for macroeconomic policy (in particular, in relation to their positions on economic austerity policies). Nor is there any consensus among economists: while some suggest that now is precisely the time to apply the lessons learnt during the Great Depression and that policymakers should implement expansionary fiscal policies, others argue that, since the high level of public sector leverage has a negative effect on economic growth, fiscal consolidation is fundamental to restoring confidence and improving expectations about the future evolution of the economy. The latter approach, which supports austerity measures, has been highly influential among the EMU authorities and has the support of the empirical evidence presented in some influential papers (Reinhart and Rogoff, 2010, among them).

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[1] During the financial crisis, public deficits increased not only because economic automatic stabilizers began to work (which meant, for instance, declining revenues) but also because of the launch of fiscal stimulus packages.

[2] In this regard, Gómez-Puig (2013) attempts to quantify the total level of indebtedness (public and private) in all euro area countries, using a database created with the statistics provided by the European Central Bank. According to her calculations, in September 2012, total leverage (public and private) over GDP recorded levels of 710%, 487%, 413%, 360% and 353% in Ireland, Portugal, Spain, Italy and Greece respectively.

Therefore, the analysis in this paper centres on EMU countries – both central (Austria, Belgium, Finland, France, Germany and the Netherlands) and peripheral (Greece, Ireland, Italy, Portugal, and Spain). However, unlike previous studies [see Baum *et al.* (2012) or Checherita-Westphal and Rother (2012)], we do not make use of panel estimation techniques to combine the power of cross section averaging with all the subtleties of temporal dependence; rather, we explore the time series dimension of the issue to obtain further evidence based on the historical experience of each country in the sample. Our econometric methodology is data-driven, and it allows us to select the statistical model that best approximates the relationship between the variables under study for any particular country and to assess both short and long-run effects of public debt on economic performance. Finally, in a departure from previous empirical analysis, we make use of a simple aggregate production function augmented for public debt to evaluate its possible influence on economic performance.

The rest of the paper is organized as follows. In Section 2 a short literature review is provided. Section 3 presents the theoretical framework of the paper and outlines the econometric methodology. Section 4 describes our data and presents our empirical results. Finally, Section 5 summarizes the findings and offers some concluding remarks.

2. Literature review

Under what conditions is debt growth-enhancing? The results from the empirical literature on the relationship between public debt and economic growth are far from conclusive (see Panizza and Presbitero (2013) for a survey). While the first studies [see, for example, Modigliani (1961), Diamond (1965) and Saint-Paul (1992)] sustained that a public debt increase always contributed to economic growth, more recent work has presented totally different results. Patillo *et al.*, (2004) conclude that whilst low levels of public debt positively affect economic growth, high levels have a negative impact; Schclarek (2005) does not find any significant relation between public debt and economic growth in industrial countries, whereas Kumar and Woo (2010), controlling for other factors that also influence growth, detected an inverse relationship between the two variables.

In their seminal work, Reinhart and Rogoff (2010) studied economic growth for different thresholds of public debt using a database of 44 countries over a time period spanning 200 years. Their results suggest that the relationship is weak for public debt ratios below 90% of GDP, but that, on average, growth rates decrease substantially above this threshold. However, since the publication of their paper, the 90% threshold has not only been questioned but has also been the focus of much of the debate in the literature, since not all debt accumulation episodes are similar: see Cecchetti *et al.* (2011), Minea and Paren (2012), Presbitero (2012), Baum *et al.* (2012), Checherita-Westphal and Rother (2012), Herdon *et al.* (2013), Égert (2013), or Afonso and Jalles (2013) to name a few.

Moreover, the recent global recession and sovereign debt crisis in Europe have stimulated an intense debate both on the effectiveness of fiscal policies and on the consequences of public debt increases, in a situation in which leverage is already very high in European economies. However, there is currently no consensus among economists in this area (see Alesina *et al.* 2015). Some suggest that now is precisely the time to implement expansionary fiscal policies [see, among others, Krugman (2011), Berg and Ostry (2011) or DeLong and Summers (2012)][3] since fiscal austerity may have been the main culprit for the recessions experienced by European countries; others claim that fiscal consolidation is essential to restore confidence in order to improve market expectations about the future evolution of the economy and therefore its rate of growth [see Cochrane (2011) or Teles and Mussolini

[3] These authors state that deleveraging policies may even prove to be detrimental, depending on the fundamental variables of the economy. Their argument is currently supported by some politicians in southern Europe.

(2014)]. In our reading of the empirical evidence, despite the sovereign debt crisis in the monetary union few papers have examined the relationship between debt and growth for euro area countries. The exceptions include Baum *et al.* (2012), Checherita-Westphal and Rother (2012), Dreger and Reimers (2013) and Antonakakis (2014). However, to our knowledge, no strong case has yet been made for analysing the incidence of debt accumulation on economic growth taking into account the particular idiosyncrasies of each euro area economy. This is the case even though the possible heterogeneity in the relationship between debt and growth across countries has recently been stressed; Eberhardt and Presbitero (2013), for instance, do not find evidence for common debt thresholds within countries over time. So, this paper aims to fill this gap in the literature. Unlike previous studies in the euro area we do not make use of panel techniques, but explore the time series dimension of the relationship in order to examine the differences within EMU countries.

3. Theoretical framework and econometric methodology

Since public debt can be seen as an alternative instrument for financing government expenditure without the need to raise existing taxes (which may create various sorts of growth-reducing distortions), when allocated to productive purposes debt may exhibit positive long-run effects on the growth rate of the economy through its impact on the productivity of private inputs. Indeed, Aschauer (1989) included public capital stock in the production function estimation since he claimed that the central aim of expansive fiscal policies was to improve the marginal productivity of the private sector's physical capital and labour (in order to raise the growth rate). Following his lead, other authors also took account of public capital stock in the production function [Devarajan *et al.* (1996), Zagler and Dürnecker (2003) or Englmann (2015), among them].

According to Devarajan *et al.* (1996), public expenditure can be divided into productive (or growth-enhancing) and unproductive (or purely consumptive) expenditure. Whilst the former, which includes physical infrastructure (roads and railways), communication, information systems (phone, internet), and education[4] may have a positive impact on the growth rate of the economy, the latter does not affect the economy's long-run performance, although it may have positive short-run implications. Therefore, the impact of an increase in the government's level of indebtedness on economic growth will depend on the kind of expenditure it funds: a long-run positive effect might be expected when it is allocated to productive purposes, while otherwise we should expect a long-run negative effect on growth[5].

Therefore, following Mankiw, Romer and Weil (1992), and consistent with the extensive empirical literature in this area, we begin our analysis by postulating a simple aggregate production function for the entire economy, in which government debt is included as a separate factor:

$$Y_t = A_t F(K_t, L_t, H_t, D_t) \qquad (1)$$

where Y_t is the level of output, A_t is an index of technological progress or total factor productivity, K_t is the stock of physical capital, L_t is the labour input, H_t is human capital, and D_t is the level of public debt.

[4] Although this sort of investment might not be profitable from the single firm's point of view (as private costs exceed private returns), the whole economy would nevertheless benefit enormously, which justifies public provision. For instance, Glomm and Ravikumar (1997) among others contend that both government infrastructure investment and education expenditures have a significant impact on an economy's long-term growth rate.

[5] Nevertheless, some authors (see Teles and Mussolini, 2014) have stressed that the positive effect of productive expenditure on economic growth may present limitations.

For simplicity, the technology is assumed to be of the Cobb-Douglas form:

$$Y_t = A_t K_t^{\alpha_1} L_t^{\alpha_2} H_t^{\alpha_3} D_t^{\alpha_4} \tag{2}$$

so that, after taking logs, and denoting by small letters the log of the corresponding capital letters, we obtain:

$$y_t = \alpha_0 + \alpha_1 k_t + \alpha_2 l_t + \alpha_3 h_t + \alpha_4 d_t \tag{3}$$

where a_{1+} $a_2+\alpha_3+\alpha_4$ would indicate the degree of returns to scale in all four inputs.

Equation (3) will be the basis of our empirical analysis. As can be seen, it postulates a technological long-run relationship between (the log of) the level of production, (the log of) the stock of physical capital, (the log of) the labour employed, (the log of) the human capital and (the log of) the public debt. This relationship can be estimated from sufficiently long time series by cointegration econometric techniques. In this paper we make use of the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration proposed by Pesaran and Shin (1991) and Pesaran, Shin and Smith (2001).

This approach presents at least three significant advantages over the two alternatives commonly used in the empirical literature: the single-equation procedure developed by Engle and Granger (1987) and the maximum likelihood method postulated by Johansen (1991, 1995) which is based on a system of equations. First, both these approaches require that the variables under study are integrated of order 1; this inevitably requires a previous process of tests on the order of integration of the series which may lead to some uncertainty in the analysis of long-run relations. In contrast, the ARDL bounds testing approach allows the analysis of long-term relationships between variables, regardless of whether they are integrated of order 0 [*I(0)*], of order 1 [*I(1)*] or mutually cointegrated. This avoids some of the common pitfalls faced in the empirical analysis of time series, such as the lack of power of unit root tests and doubts about the order of integration of the variables examined. Second, the ARDL bounds testing approach allows a distinction to be made between the dependent variable and the explanatory variables, an obvious advantage over the method proposed by Engle and Granger; while, like the Johansen approach, it enables simultaneous estimation of the short-run and long-run components, eliminating the problems associated with omitted variables and the presence of autocorrelation. Finally, while the estimation results obtained by the methods proposed by Engle and Granger and Johansen are not robust to small samples, Pesaran and Shin (1991) show that the short-run parameters estimated using their approach are $\sqrt{T}-$consistent and the long-run parameters are super-consistent in small samples.

In our particular case, the application of the ARDL approach to cointegration involves estimating the following unrestricted error correction model (UECM):

$$\begin{aligned}\Delta y_t &= \beta + \sum_{i=1}^{p}\gamma_i \Delta y_{t-i} + \sum_{i=1}^{p}\omega_i \Delta k_{t-i} + \sum_{i=1}^{p}\varphi_i \Delta l_{t-i} + \sum_{i=1}^{p}\upsilon_i \Delta h_{t-i} + \sum_{i=1}^{p}\phi_i \Delta d_{t-i} + \\ &+ \lambda_1 y_{t-1} + \lambda_2 k_{t-1} + \lambda_3 l_{t-1} + \lambda_4 h_{t-1} + \lambda_5 d_{t-1} + \varepsilon_t\end{aligned} \quad (4)$$

where Δ denotes the first difference operator, β is the drift component, and ε_t is assumed to be a white noise process. The ARDL approach estimates $(p+1)^k$ number of regressions to obtain the optimal lag length for each series, where p is the maximum number of lags used and k is the number of variables in equation (3). The optimal lag structure of the first differenced regression is selected by the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) to ensure that there is no serial correlation. In order to determine the existence of long-run relationship between the variables under study, Pesaran, Shin and Smith (2001) propose two alternative tests. First, an *F-statistic* is used to test the joint significance of the first lag of the variables in levels used in the analysis (i. e.

$\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$). Furthermore, a *t-statistic* is used to test the individual significance of the lagged dependent variable in levels (i. e. $\lambda_1 = 0$).

Pesaran, Shin and Smith (2001) provide a set of critical values assuming first that the variables under study are *I(1)* and, secondly, that such variables are *I(0)*. These authors propose a bounds testing procedure: if the calculated *F*-or *t*-statistics exceed the upper critical bound (UCB), we conclude in favour of a long-run relationship, regardless of the order of integration. However, if these statistics are below the lower critical bound (LCB), the null hypothesis of no cointegration cannot be rejected. Finally, if the calculated *F*- and *t*-statistics are between UCB and LCB, then the decision about cointegration is inconclusive. When the order of integration for all series is *I(1)* then the decision is based on the UCB; and if all the series are *I(0)*, it is based on the LCB.

The test statistics based on equation (4) have a different distribution under the null hypothesis of no level relationships, depending on whether the regressors are all *I(0)* or all *I(1)*. Further, under both cases the distribution is non-standard. Pesaran, Shin and Smith (2001) provide critical values for the cases where all regressors are *I(0)* and the cases where all regressors are *I(1)*, and suggest that these critical values be used as bounds for the more typical cases where the regressors are a mixture of *I(0)* and *I(1)*.

If cointegration exists, the conditional long-run model is derived from the reduced form equation (4) when the series in first differences are jointly equal to zero (i. e., $\Delta y = \Delta k = \Delta l = \Delta d = 0$). The calculation of these estimated long-run coefficients is given by:

$$y_t = \delta_1 + \delta_2 k_t + \delta_3 l_t + \delta_4 h_t + \delta_5 d_t + \xi_t \qquad (5)$$

where $\delta_1 = \frac{-\beta}{\lambda_1}$; $\delta_2 = \frac{-\lambda_2}{\lambda_1}$; $\delta_3 = \frac{-\lambda_3}{\lambda_1}$; $\delta_4 = \frac{-\lambda_4}{\lambda_1}$; $\delta_5 = \frac{-\lambda_5}{\lambda_1}$; and ξ_t is a random error. The standard error of these long-run coefficients can be calculated from the standard errors of the original regression using the delta method.

Finally, if a long-run relation is found, an error correction representation exists which is estimated from the following reduced form equation:

$$\Delta y_t = \sum_{i=1}^{p} \theta_i \Delta y_{t-1} + \sum_{i=1}^{q_1} \varpi_i \Delta k_{t-1} + \sum_{i=1}^{q_2} \pi_i \Delta l_{t-1} + \sum_{i=1}^{q_3} \tau_i \Delta h_{t-1} + \sum_{i=1}^{q_4} \kappa_i \Delta d_{t-1} + \eta ECM_{t-1} \quad (6)$$

4. Data and empirical results

4.1. Data

We estimate equation (6) with annual data for eleven EMU countries: both central (Austria, Belgium, Finland, France, Germany and the Netherlands) and peripheral countries (Greece, Ireland, Italy, Portugal and Spain)[6]. Even though the ARDL-based estimation procedure used in the paper can be reliably used in small samples, we use long spans of data covering the period 1960-2012 (i.e., a total of 42 observations) to explore the dimension of historical specificity and to capture the long-run relationship associated with the concept of cointegration (see, e. g., Hakkio and Rush, 1991).

[6] This distinction between central and peripheral countries has been extensively used in the empirical literature. The two groups we consider roughly correspond to the distinction made by the European Commission (1995) between those countries whose currencies continuously participated in the European Exchange Rate Mechanism (ERM) from its inception and which maintained broadly stable bilateral exchange rates with each other over the sample period, and those countries whose currencies either entered the ERM later or suspended their participation in the ERM, as well as fluctuating in value to a great extent relative to the Deutschmark. These two groups are also roughly the ones found in Jacquemin and Sapir (1996), who applied multivariate analysis techniques to a wide set of structural and macroeconomic indicators, to form a homogeneous group of countries. Moreover, these two groups are basically the same as the ones found in Ledesma-Rodríguez et al. (2005) according to economic agents' perceptions of the commitment to maintain the exchange rate around a central parity in the ERM, and those identified by Sosvilla-Rivero and Morales-Zumaquero (2012) using cluster analysis when analysing permanent and transitory volatilities of EMU sovereign yields.

To maintain as much homogeneity as possible for a sample of 11 countries over the course of six decades, our primary source is the European Commission´s AMECO database[7] covering the period 1960-2012. We then strengthen our data with the use of supplementary data sourced from International Monetary Fund (International Financial Statistics) and the World Bank (World Development Indicators). We use GDP, capital stock and public debt at 2010 market prices for the level of output (Y_t), the stock of physical capital (K_t) and the level of public debt (D_t), and civilian employment and life expectancy at birth for indicators of the labour input (L_t) and human capital (H_t)[8]. The precise definitions and sources of the variables are given in Appendix 1.

4.2. Preliminary results

Before proceeding towards the ARDL cointegration exercise, we test for the order of integration of the variables by means of the Augmented Dickey-Fuller (ADF) tests. This is necessary just to ensure that none of our variables is only stationary at second differences (i. e., *I(2)*). The results, shown in Table 1, decisively reject the null hypothesis of non-stationarity, suggesting that both variables can be treated as first-difference stationary[9].

[Insert Table 1 here]

We also compute the Kwiatkowski *et al.* (1992) (KPSS) tests, where the null is a stationary process against the alternative of a unit root. As argued by Cheung and Chinn (1997), the ADF and KPSS tests can be viewed as complementary, rather than in competition with one

[7] http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm

[8]Other proxies commonly used for human capital such as years of secondary education and school enrollment in secondary were available only from 1980. Additionally, the proxy years of secondary education did not change during the sample period.

[9]These results were confirmed using Phillips-Perron (1998) unit root tests controlling for serial correlation and the Elliott, Rothenberg, and Stock (1996) Point Optimal and Ng and Perron (2001) unit root tests for testing non-stationarity against the alternative of high persistence. These additional results are not shown here for reasons of space, but they are available from the authors upon request

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another; therefore, we can use the KPSS tests to confirm the results obtained by the ADF tests. As can be seen in Table 2, the results fail to reject the null hypothesis of stationarity in first-difference but strongly reject it in levels.

[Insert Table 2 here]

The single order of integration of the variables encourages the application of the ARDL bounds testing approach to examine the long-run relationship between the variables.

4.3. Empirical results from the ARDL bounds test

The estimation proceeds in stages. In the first stage, we specify the optimal lag length for the model (in this stage, we impose the same number of lags on all variables as in Pesaran, Shin and Smith, 2001). The ARDL representation does not require symmetry of lag lengths; each variable may have a different number of lag terms. As mentioned above, we use the AIC and SBC information criteria to guide our choice of the lag length. For the test of serial correlation in the residual, we use the maximum likelihood statistics for the first and fourth autocorrelation, denoted as $\chi^2_{SC}(1)$ and $\chi^2_{SC}(4)$ respectively. These results are not shown here to save space, but they are available from the authors upon request.

Next we test for the existence of a long-run relation between the output and its components as suggested by equation (3). Table 3 gives the values of the *F*- and *t*-statistics for the case of unrestricted intercepts and no trends (case III in Pesaran, Shin and Smith, 2001)[10]. These statistics are compared with the critical value bounds provided in Tables CI and CII of Pesaran, Shin and Smith (2001) and depend on whether an intercept and/or trend is included in the estimations.

[10] We also consider two additional scenarios for the deterministics: unrestricted intercepts, restricted trends; and unrestricted intercepts, unrestricted trends (cases IV and V in Pesaran, Shin and Smith, 2001). These additional results are not shown here for reasons of space, but they are available from the authors upon request. Nevertheless, our estimation results indicate that the intercepts are always statistically significant, but not the trends.

[Insert Table 3 here]

The estimated long-run relationships between the variables are reported in Table 4.

[Insert Table 4 here]

In order to examine the short-term dynamics of the model, we estimate an error-correction model associated with the above long-run augmented production function. These results are reported in Table 5, which shows that the short-run analysis seems to pass diagnostic tests such as normality of error term, second-order residual autocorrelation and heteroskedasticity (χ^2_{N}, χ^2_{SC} and χ^2_{H} respectively).

[Insert Table 5 here]

Finally, we examine the stability of long-run coefficients using the CUSUM and CUSUM squares tests (Figures 1 and 2). These tests are applied recursively to the residuals of the error-correction model shown in Table 5. Since the test statistics remain within their critical values (at a marginal significance level of 5%), we are able to confirm the stability of the estimated long-run equation.

[Insert Figures 1 and 2 here]

Thus, the following results can be drawn from Tables 4 and 5. First, the long-term effect of debt on economic performance is negative in all EMU countries; France (-0.5439), Spain (-0.3356) and Portugal (-0.3356) are the countries with highest negative impact, and Ireland (-0.0492), Finland (-0.0490) and Germany (-0.0397) the ones with the lowest negative impact. So, according to our results the impact of an increase in the government's level of indebtedness on economic activity is always negative, regardless of the kind of expenditure (productive or unproductive) it may fund.

Second, regarding EMU peripheral countries, it is interesting to note that in Greece, Ireland and Italy an increase in public debt has a negative effect on GDP not only in the long run but in the short run as well. In Portugal and Spain, however, in spite of its important negative impact in the long run, its effect in the short run is positive (one period lagged in the case of Portugal).

And third, with respect to EMU central countries, it is noticeable that in Germany and Finland the effect of public debt on GDP is positive in the short run (one period lagged), and negative (though very small) in the long run. Similar results are found in the case of Austria (though the long-run negative effect is larger). Finally, in the case of Belgium and France our results suggest that public debt has a negative impact on economic activity both in the short and in the long run (in the case of France, the negative long-run impact is the highest).

These results suggest that in two peripheral (Spain and Portugal) and three central countries (Germany, Finland and Austria), public debt may have been funding unproductive (or purely consumptive) expenditure. This may have had positive implications, but only in the short run (see Devarajan *et al.*, 1996).

Nevertheless, we did not find a positive long-run relationship between public debt and output in any country. This suggests that, even though some public debt may have been funding productive expenditure, its volume was not large enough to enhance economic activity. Besides, the fact that we have explored the impact of public debt on output during a time period that covers five decades (1960-2012) and extends beyond the economic and sovereign debt crisis (see Figures 3 and 4) may have distorted the results, in view of the sudden and significant rise in European countries' public debt levels following government interventions in response to global financial crisis (not only fiscal stimulus programmes and bank bailouts, but also social safety nets that work as economic automatic stabilizers by responding to the increase in the unemployment rate).

[Insert Figures 3 and 4 here]

So, in the next sub-section we analyse the time-varying impact of public debt on short-term economic performance, splitting our sample into several sub-periods that were defined by the Euro Area Business Cycle Dating Committee[11], based on a methodology analogous to the one used to determine the Economic Cycle Research Institute's (ECRI) international business cycle dates[12]. In particular, the following business cycles have been detected for EMU economies during the 1960-2012 sample period: (1) 1960-1974; (2) 1975-1992; (3) 1993-2007; and (4) 2008-2012. However, due to estimation constraints, we only re-estimate the short-run model for two sub-periods [(a) 1975-1992 and (b) 1993-2007] and analyse whether the impact of government debt on output differs between them[13].

4.4. Time-varying impact of public debt on economic performance.

The short-run analysis for the two sub-samples, (a) 1975-1992 and (b) 1993-2007, in each EMU country is presented in Table 6.

[Insert Table 6 here]

The diagnostic tests reported in Table 6 do not show any sign of misspecification in the estimated equations. Besides, the most important results that can be drawn from this table are the following. In the case of central countries, whilst in the Netherlands public debt has a positive impact on output during the second sub-period (1993-2007), in France and Germany the effect is positive through both sub-periods (1975-1992 and 1993-2007).

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11 See Center for Economic Policy Research (2014).

12 See https://www.businesscycle.com/ecri-business-cycles/international-business-cycle-dates-chronologies

13 The sudden, significant rise in government debt levels following government interventions in response to the global financial crisis beyond 2007 (see Figure 3) is another of the reasons why we do not extend the analysis beyond this date.

Regarding peripheral countries we also find a positive impact of debt on output during the second sub-period (1993-2007) in the case of Greece, Ireland and Italy, and in the first one (1975-1992) in the case of Spain.

These results may qualify the findings obtained for the whole sample, which suggested that in two peripheral (Spain and Portugal) and three central countries (Germany, Finland and Austria), public debt had a positive effect on output, though only in the short run.

Therefore, taking together the short-run results obtained for the whole sample and the two sub-samples (Tables 5 and 6), we may cautiously conclude that although the effect of public debt on output is always negative in the long run, it may be positive in the short run. This appears to have been the case of Germany and Spain during the sample periods 1975-2007 and 1975-1992 respectively.

5. Concluding remarks

In this paper we have examined the possible influence of public debt on economic performance in eleven EMU countries (both central and peripheral) during the 1960-2012 period. To this end, we estimated a simple aggregate production function for total output including public debt as a separate factor for each country. Therefore, this study endeavours to fill the current research gap caused by the use of panel-data techniques to analyse the relationship between debt and output, which do not allow distinctions to be made between countries.

The results obtained by using the ARDL bounds testing approach to cointegration suggest a negative effect of public debt on output in the long run, but admit the possibility of a positive effect in the short run depending on the characteristics of the country and of the final allocation of public debt. We do not claim that the results are infallible, but we stress that they are based on widely accepted econometric tools and techniques as well as on sound economic logic. Nevertheless, further research is needed in order to identify the macroeconomic determinants of public debt, since its effects may differ according to its allocation: that is, to productive (or growth-enhancing) public expenditure, or to unproductive (or purely consumptive) expenditure (see Devarajan *et al.*, 1996).

Acknowledgements

This paper is based upon work supported by the Government of Spain and FEDER under grant number ECO2011-23189 and ECO2013-48326. Marta Gómez-Puig also thanks the Instituto de Estudios Fiscales for financial support (project IEF 101/2014). Simón Sosvilla-Rivero thanks the Universitat de Barcelona & RFA-IREA for their hospitality. Responsibility for any remaining errors rests with the authors.

Appendix 1: Definition of the explanatory variables and data sources

Variable	Description	Source
Level of Output (Y_t)	Gross domestic product at 2010 market prices	Annual Macroeconomic Database-European Commission (AMECO)
Capital Stock (K_t)	Net capital stock at 2010 market prices	AMECO
Level of public debt (D_t)	General government consolidated gross debt at 2010 market prices	AMECO and International Monetary Fund
Labour input (L_t)	Civilian employment	AMECO
Human capital (H_t)	Life expectancy at birth, total (years)	World Development Indicators, World Bank

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Table 1. Augmented Dickey-Fuller tests for unit roots.

Panel A: I (2) versus I (1) (Variables in first differences)				
Country	**Variable**	τ_τ	τ_μ	**T**
AT	Δ***y***	--6.5127	-5.1999*	-2.7422*
	Δ***k***	-4.3308*	-3.6206*	-2.8238*
	Δ**l**	-5.9083*	-5.3123*	-4.5947*
	Δ***h***	-9.9420*	-9.9180*	-2.7413*
	Δ***d***	-5.7918*	-5.6235*	-2.7181*
BE	Δ***y***	-6.7061*	-5.0801*	-2.9577*
	Δ***k***	-4.2892*	-3.7822*	-2.6954*
	Δ**l**	-4.8361*	-4.5554*	-4.1708*
	Δ***h***	-11.0268*	-11.0715*	-3.2521*
	Δ***d***	-7.2830*	-3.7436*	-2.7532*
FI	Δ***y***	-4.8867*	-4.5320*	-3.3071*
	Δ***k***	-3.7701**	-3.8441*	-2.6211*
	Δ**l**	-4.5945*	-4.6448*	-4.6380*
	Δ***h***	-5.9301*	-4.0088*	-3.0615*
	Δ***d***	-4.1571**	-4.2012*	-3.5862*
FR	Δ***y***	-4.8869*	-4.5320*	-3.3071*
	Δ***k***	-3.6816**	-3.0692**	-2.8730*
	Δ**l**	-4.8908*	-4.9177*	-2.9013*
	Δ***h***	-7.0261*	-7.0713*	-3.2521*
	Δ***d***	-4.6158*	-4.6150*	-4.1180*
GE	Δ***y***	-6.6679*	-5.1871*	-3.3196*
	Δ***k***	-3.7030**	-3-6413*	-2.7401*
	Δ**l**	-5.9950*	-5.7201*	-5.2289*
	Δ***h***	-7.9188*	-7.4507*	-2.6810*
	Δ***d***	-4.7909*	-4.4196*	-2.5651**
GR	Δ***y***	-4.9108*	-3.8706*	-3.5100*
	Δ***k***	-4.1123**	-3.6180*	-2.6658*
	Δ**l**	-4.1775*	-3.2877**	-2.7391*
	Δ***h***	-7.5080*	-6.7105*	-2.8612*
	Δ***d***	-9.1968*	-8.5823*	-2.8743*
IE	Δ***y***	-3.9471**	-3.5356*	-2.7748*
	Δ***k***	-4.0129**	-3.7324*	-2.6380*
	Δ**l**	-4.7243*	-3.9504*	-3.1723*
	Δ***h***	-5.2499*	-3.1738**	-2.6364*
	Δ***d***	-3.6018**	-3.6301*	--3.1692*
IT	Δ***y***	-6.9406*	-4.2181*	-2.6475*
	Δ***k***	-4.5159*	-3.5312**	-2.7899*
	Δ**l**	-4.0228**	-4.0473*	-4.0761*
	Δ***h***	-5.7923*	-4.0831*	-2.9108*
	Δ***d***	-4.6082*	-3.6530*	-2.9241*
NL	Δ***y***	-4.3834*	-3.4255**	-2.6215*
	Δ***k***	-4.2530*	-3.1562**	-2-6234*
	Δ**l**	-5.7439*	-5.8074*	-4.5647*
	Δ***h***	-9.0270*	-8.5068*	-2.9240*
	Δ***d***	-5.3582*	-4.9341*	-3.8121*
PT	Δ***y***	-4.7999*	-3.5718*	-2.5546**
	Δ***k***	-4.2971*	-2.9443**	-2.5840**
	Δ**l**	-4.7487*	-4.7232*	-4.6853*
	Δ***h***	-5.7846*	-5.4675*	-2.7329*
	Δ***d***	-4.0644**	-3.9994*	-2.8629*
SP	Δ***y***	-3.5807**	-3.6355*	-2.6507*
	Δ***k***	-3.9787**	-3.3918**	-2.7152*
	Δ**l**	-4.4395*	-3.6134*	--2.7684*
	Δ***h***	-7.1213*	-6.9283*	-2.7529*
	Δ***d***	-3.6815**	-3.8129*	--2.8241*

Table 1 (Continued)

Panel B: I (1) versus I (0) (Variables in levels)				
Country	**Variable**	τ_τ	τ_μ	**T**
AT	***y***	-1.3393	-2.4451	2.3954
	k	-0.6238	-2.4602	-0.0349
	l	-2.1348	1.6423	3.5707
	h	-2.2066	-0.2614	1.9615
	d	-3.0156	1.1100	3.5156
BE	***y***	-2.0986	-2-1541	1.7470
	k	-1.7936	-2.5072	0.6156
	l	-1.3175	0.3671	1.8619
	h	-3.1226	-1.0485	0.6528
	d	-1.3880	-1.2012	1.3224
FI	***y***	-1.4191	-1.8605	2.5771
	k	-1.7451	-2.3438	0.9656
	l	--3.0428	-2.4541	0.5916
	h	-2.4975	0.2117	2.7514
	d	-1.8771	-0.7870	1.5818
FR	***y***	-1.5816	-2.0082	1.3944
	k	-1.8122	-2.3024	0.7936
	l	-1.9436	-1.6164	0.9568
	h	-3.1226	0.4458	2.5123
	d	-3-0927	-0.1796	1.8067
GE	***y***	-1.5816	-2.0082	1.3944
	k	-1.8122	-2.3024	0.7936
	l	-1.9436	-1.6164	0.9568
	h	-2.2338	-1.5692	1.3238
	d	-0.3146	-1.6901	2.5730
GR	***y***	-1.0010	-2.3408	1.3569
	k	-1.5597	-2.4808	-0.5418
	l	-2.2558	-2.0543	-0.3281
	h	-1.5812	-0.7191	1.5861
	d	-1.1751	-1.4518	1.1216
IE	***y***	-1.9512	-0.8449	2.2557
	k	-3.0149	-1.6303	0.9326
	l	-1.9729	-0.3138	1.3973
	h	-2.1733	-2.0531	-1.2554
	d	-2.2974	-0.7554	1.4304
IT	***y***	-2-1720	-0.5518	2.3052
	k	-2.4669	-0.5135	0.6318
	l	-3.1509	-1.2592	0.3692
	h	-0.5641	-1.4814	2.0789
	d	-0.5985	-2.4603	2.1287
NL	***y***	-1.8167	-2.4855	2.2671
	k	-2.7912	-2.4371	0.1985
	l	-1.2728	-0.2763	1.7524
	h	-2.2529	-0.1643	1.9099
	d	-1.3819	-0,1586	1.0583
PT	***y***	-0.7924	-2.1028	1.8841
	k	0.5611	-2.0484	0.1611
	l	-1.3539	-1.1791	0.7371
	h	-1.8500	-2.3604	1.7143
	d	-1.0314	-1.0858	1.2001
SP	***y***	-1.5694	-2.1594	1.5243
	k	-1.9370	-2.1556	1.6316
	l	-2.4506	-1.6025	0.4907
	h	-1.7033	-1.4070	1.7045
	d	-2.2347	-0.3025	1.8015

Notes: The ADF statistic is a test for the null hypothesis of a unit root.
τ_τ, τ_μ and τ denote the ADF statistics with drift and trend, and with and without drift respectively.
* and ** denote significance at the 1% and 5% levels respectively. Critical values based on MacKinnon (1996)
AT, BE, FI, FR, GE, GR, IE, IT, NL, PT and SP stand for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain respectively.

Table 2. KPSS tests for stationarity

Panel A: I (2) versus I (1) (Variables in first differences)			
Country	**Variable**	τ_τ	τ_μ
AT	$\Delta\boldsymbol{y}$	0.0812	0.3165
	$\Delta\boldsymbol{k}$	0.0675	0.0304
	$\Delta\boldsymbol{l}$	0.1068	0.3145
	$\Delta\boldsymbol{h}$	0.1023	0.1011
	$\Delta\boldsymbol{d}$	0.1129	0.2232
BE	$\Delta\boldsymbol{y}$	0.1118	0.3379
	$\Delta\boldsymbol{k}$	0.0580	0.3120
	$\Delta\boldsymbol{l}$	0.0943	0.3108
	$\Delta\boldsymbol{h}$	0.0938	0.0936
	$\Delta\boldsymbol{d}$	0.1073	0.2062
FI	$\Delta\boldsymbol{y}$	0.0679	0.3146
	$\Delta\boldsymbol{k}$	0.1125	0.3560
	$\Delta\boldsymbol{l}$	0.0596	0.0611
	$\Delta\boldsymbol{h}$	0.0820	0.0892
	$\Delta\boldsymbol{d}$	0.1033	0.1060
FR	$\Delta\boldsymbol{y}$	0.0679	0.3126
	$\Delta\boldsymbol{k}$	0.1239	0.2678
	$\Delta\boldsymbol{l}$	0.0784	0.0779
	$\Delta\boldsymbol{h}$	0.0934	0.0936
	$\Delta\boldsymbol{d}$	0.1032	0.1938
GE	$\Delta\boldsymbol{y}$	0.1118	0.3324
	$\Delta\boldsymbol{k}$	0.1075	0.3144
	$\Delta\boldsymbol{l}$	0.1110	0.2663
	$\Delta\boldsymbol{h}$	0.1042	0.3154
	$\Delta\boldsymbol{d}$	0.1121	0.3270
GR	$\Delta\boldsymbol{y}$	0.1065	0.3143
	$\Delta\boldsymbol{k}$	0.1107	0.3385
	$\Delta\boldsymbol{l}$	0.1065	0.1740
	$\Delta\boldsymbol{h}$	0.0636	0.3166
	$\Delta\boldsymbol{d}$	0.0496	0.3061
IE	$\Delta\boldsymbol{y}$	0.1114	1.1288
	$\Delta\boldsymbol{k}$	0.0697	0.1748
	$\Delta\boldsymbol{l}$	0.1017	0.2174
	$\Delta\boldsymbol{h}$	0.0598	0.3140
	$\Delta\boldsymbol{d}$	0.1082	0.1076
IT	$\Delta\boldsymbol{y}$	0.0826	0.3291
	$\Delta\boldsymbol{k}$	0.0864	0.3267
	$\Delta\boldsymbol{l}$	0.0751	0.1335
	$\Delta\boldsymbol{h}$	0.1052	0.2715
	$\Delta\boldsymbol{d}$	0.0891	0.3154
NL	$\Delta\boldsymbol{y}$	0.0972	0.2974
	$\Delta\boldsymbol{k}$	0.0912	0.3146
	$\Delta\boldsymbol{l}$	0.1015	0.1524
	$\Delta\boldsymbol{h}$	0.0648	0.2608
	$\Delta\boldsymbol{d}$	0.0992	0.2619
PT	$\Delta\boldsymbol{y}$	0.0648	0.3184
	$\Delta\boldsymbol{k}$	0.1039	0.2679
	$\Delta\boldsymbol{l}$	0.1017	0.1912
	$\Delta\boldsymbol{h}$	0.0853	0.2618
	$\Delta\boldsymbol{d}$	0-1044	0.2150
SP	$\Delta\boldsymbol{y}$	0.1175	0.2670
	$\Delta\boldsymbol{k}$	0.0639	0.2528
	$\Delta\boldsymbol{l}$	0.0878	0.1125
	$\Delta\boldsymbol{h}$	0.1150	0.2207
	$\Delta\boldsymbol{d}$	0.0806	0.0790

Table 2 (Continued)

Panel B: I (1) versus I (0) (Variables in levels)			
Country	**Variable**	τ_τ	τ_μ
AT	***y***	0.2249*	0.8641*
	k	0.2487*	0.8682*
	l	0.2198*	0.8092*
	h	0.2470*	0.8737*
	d	0.2261*	0.8394*
BE	***y***	0.2171*	0.8634*
	k	0.2335*	0.8706*
	l	0.2238*	0.8244*
	h	0.2368*	0.8749*
	d	0.2634*	0.7943*
FI	***y***	0.2199*	0.8604*
	k	0.2568*	0.8670*
	l	0.2776*	0.5317**
	h	0.2950*	0.8720*
	d	0.2386*	0.7864*
FR	***y***	0.2349*	0.8648*
	k	0.2419*	0.8593*
	l	0.2195*	0.9126*
	h	0.1995**	0.8604*
	d	0.1532**	0.8377*
GE	***y***	0.2349*	0.8648*
	k	0.2419*	0.8593*
	l	0.2195*	0.9126*
	h	0.1763**	0.8788*
	d	0.2226*	0.8645*
GR	***y***	0.1885**	0.8998*
	k	0.2449*	0.8242*
	l	0.2038**	0.7367*
	h	0.2352*	0.8741*
	d	0.1988**	0.8221*
IE	***y***	0.1786**	0.8617*
	k	0.1889*	0.8693*
	l	0.2182*	0.7515*
	h	0.2235*	0.8038*
	d	0.1988**	0.8926*
IT	***y***	0.2442*	0.8301*
	k	0.2604*	0.8597*
	l	0.2762*	0.7464*
	h	0.2135**	0.8789*
	d	0.2440*	0.8250*
NL	***y***	0.2164*	0.8650*
	k	0.2243*	0.8592
	l	0.1628**	0.8434*
	h	0.1509**	0.8612*
	d	0.1561**	0.9626*
PT	***y***	0.2331*	0.8541*
	k	0.1533**	0.8666*
	l	0.2141**	0.7869*
	h	0.2337*	0.8722*
	d	0.1048*	0.8334*
SP	***y***	0.1694**	0.8610*
	k	0.1643**	0.8772*
	l	0.1983**	0.7596*
	h	0.1926**	0.8762*
	d	0.2987*	0.8994*

Notes: The KPSS statistic is a test for the null hypothesis of stationarity.
τ_τ and τ_μ denote the KPSS statistics with drift and trend, and with drift respectively.
* and ** denote significance at the 1% and 5% levels respectively. Asymptotic critical values based on Kwiatkowski *et al.* (1992. Table 1)
AT, BE, FI, FR, GE, GR, IE, IT, NL, PT and SP stand for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain respectively.

Table 3. *F*- and *t*-statistics for testing the existence of the long-run model

Country	Bound testing to cointegration		
	ARDL(p,q_1,q_2,q_3,q_4,q_5)	***F*-statistic**	***t*-statistic**
AT	(4, 3, 3, 4, 4)	6.8148*	-5.2908*
BE	(1, 2, 4, 4, 0)	5.0451**	-3.7093**
FI	(1, 4, 3, 1, 2)	5.0352**	-3.8220**
FR	(1, 0, 2, 4, 3)	4.1633**	-3.8685**
GE	(2, 2, 1, 0, 2)	6.0071*	-4.7023*
GR	(1, 3, 0, 0, 0)	4.5088**	-3.6953**
IE	(1, 2, 1, 0, 0)	4.6117**	-3.7436**
IT	(3, 2, 0, 4, 1)	5.3960*	-3.6283**
NL	(1, 4, 3, 4, 4)	6.7727*	-4.2859*
PT	(1, 3, 3, 0, 2)	4.3225**	-3.8598**
SP	(1, 3, 2, 0, 3)	4.3497**	-4.0635**

Notes: p,q_1,q_2,q_3,q_4 and q_5 denote respectively the optimal lag length for Δy_{t-i}, Δk_{t-i}, Δl_{t-i}, Δh_{t-i} and Δd_{t-i} in the UECM model (4) without deterministic trend.

* and ** indicate that the calculated *F*- and *t*-statistics are above the upper critical bound at 1% and 5% respectively.

AT, BE, FI, FR, GE, GR, IE, IT, NL, PT and SP stand for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain respectively.

Table 4. Long-run analysis

Country	Estimation results
AT	y_t= -0.0041 + 0.2964k_t + 0.3278l_t + 0.0855h_t - 0.1288d_t (-3.0331) (6.6280) (6.1756) (2.8922) (-4.3352)
BE	y_t= -0.0982 + 0.3963k_t+ 0.4515l_t+ 0.4210h_t- 0.0621d_t (-3.2144) (6.0705) (7.7879) (2.9783) (-5.5117)
FI	y_t= -0.0632 + 0.4261k_t + 0.4112l_t+ 0.5375h_t - 049021d_t (-3.5612) (5.6646) (7.2917) (4.13723) (-5.1371)
FR	y_t= -0.0504 + 0.4288$_t$ + 0.4277l_t+ 0.5068h_t – 0.5439d_t (-3.6212) (5.8255) (3.8349) (3.9981) (-5.8665)
GE	y_t= -0.0633 +0.4970k_t + 0.5204l_t+ 0.5843h_t - 0.0397d_t (-3.0207) (5.5325) (2.9449) (2.9769) (-2.9149)
GR	y_t= -0.1547 +0.2445k_t + 0.3115l_t+ 0.3457h_t - 0.0787d_t (-3.0207) (5.4884) (3.4825) (2.9321) (-3.1347)
IE	y_t= 0.3738 +0.2324k_t + 0.3945l_t+ 0.1311h_t - 0.0492d_t (2.9965) (6.1718) (3.5311) (3.1237) (-7.7831)
IT	y_t= 0.2315 +0.3117k_t + 0.4720l_t+ 0.1422h_t - 0.0831d_t (-3.1429) (5. 8428) (6.3747) (3.7232) (-6.7227)
NL	y_t= 0.0222 +0.4435k_t + 0.3576l_t+ 0.3571h_t - 0.0966d_t (3.0545) (6.2867) (6.3197) (4.1977) (-7.3175)
PT	y_t= 0.2740 +0.3297k_t + 0.3732$_t$+ 0.2054h_t - 0.3536d_t (3.0336) (4.2039) (2.9423) (2.9473) (-6.3360)
SP	y_t= -0.0615 +0.4891k_t + 0.3241$_t$+ 0.3527h_t - 0.3356d_t (-3.0515) (7.3996) (4.0399) (3.3946) (-4.8721)

Notes: In the ordinary brackets below the parameter estimates are the corresponding *t*-statistics.
AT, BE, FI, FR, GE, GR, IE, IT, NL, PT and SP stand for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain respectively.

Table 5. Short-run analysis: Whole sample

Country		Adjusted R^2	DW Test	χ^2_N	χ^2_{SC}	χ^2_H
AT	$\Delta y_t = 0.3357\Delta y_{t-1} + 0.2273\Delta y_{t-2} + 3.4635\Delta k_t + 1.6406\Delta k_{t-1} +$ (4.9587) (3.9848) (7.1120) (3.2281) $+ 0.5122\Delta l_t + 1.8360\Delta h_{t-1} - 0.1050\Delta d_t + 0.1169\Delta d_{t-1}$ (4.2105) (3.8970) (-3.5605) (3.5604) $+ 0.0771\Delta d_{t-3} - 0.7184 ECM_{t-1}$ (3.0602) (-7.5397)	0.8052	2.1035	1.3631 [0.5058]	0.4403 [0.8024]	6.7833 [0.7457]
BE	$\Delta y_t = 2.9234\Delta k_t + 1.9681\Delta k_{t.1} + 0.5450\Delta l_t + 2.1247.\Delta h_{t-1}$ (6.4798) (4.4537) (3.3954) (3.7914) $+ 1.8736\Delta h_{t-2} + 1.2525\Delta h_{t-3} - 0.0186\Delta d_t - 0.3011 ECM_{t-1}$ (3.5399) (3.5437) (-4.3458) (-4.3245)	0.6991	2.1682	0.7188 [0.6980]	1.6363 [0.4412]	8.7743 [0.5536]
FI	$\Delta y_t = 3.9141\Delta k_t + 4.2948\Delta k_{t-1} + 2.0681\Delta k_{t-2} + 0.7669\Delta l_t$ (5.9736) (6.5524) (3.8293) (5.3695) $+ 0.1491\Delta l_{t-2} + 1.2080\Delta h_t + 0.0589\Delta d_{t-1} - 0.5431 ECM_{t-1}$ (3.2632) (3.9132) (4.9503) (-5.0585)	0.8947	2.1812	1.8337 [0.3998]	0.6935 [0.7070]	8.3739 [0.3978]
FR	$\Delta y_t = 0.5483\Delta k_t + 2.7066\Delta l_t + 1.3583\Delta l_{t-2} + 2.7571\Delta h_{t-1}$ (4.1446) (6.7447) (3.2368) (3.4479) $- 0.0540\Delta d_{t-1} - 0.1594 ECM_{t-1}$ (-3.2524) (-4.7831)	0.6250	2.0703	1.0284 [0.5980]	2.7751 [0.2497]	11.6117 [0.1514]
GE	$\Delta y_t = 0.1245\Delta y_{t-1} + 4.5310\Delta k_t + 2.9485\Delta k_{t-1} + 0.6069\Delta l_t$ (3.4013) (6.2536) (-4.8966) (5.0089) $+ 0.3283\Delta h_t + 0.0888\Delta d_{t-1} - 0.5431 ECM_{t-1}$ (3.5278) (3.3255) (-5.7911)	0.8654	2.0727	1.7700 [0.4127]	2.0859 [0.3524]	8.8985 [0.3509]
GR	$\Delta y_t = 4.1491\Delta k_t + 2.2586\Delta k_{t-1} + 0.3111\Delta l_t - 0.0195\Delta d_{t-1}$ (5.6965) (4.4863) (3.2133) (-3.7315) $- 0.1898 ECM_{t-1}$ (-5.3528)	0.8233	2.0170	1.6641 [0.4352]	1.7768 [0.4113]	2.7153 [0.7438]
IE	$\Delta y_t = 4.1491\Delta k_{t-1} + 0.5946\Delta l_t + 3.6624\Delta h_{t-1}$ (4.2518) (5.2966) (3.3309) $- 0.0770\Delta d_t - 0.0750 ECM_{t-1}$ (-3.9022) (-6.8543)	0.6679	1.9876	0.4433` [0.8012]	2.6952 [0.2599]	6.6772 [0.2458]
IT	$\Delta y_t = 0.2820\Delta y_{t-1} + 0.1810\Delta y_{t-1} + 5.3075\Delta k_t + 3.4087\Delta k_{t-1}$ (3.9118) (3.5678) (7.7289) (6.6994) $+ 0.1468\Delta l_t + 0.8079\Delta h_{t-3} - 0.0770\Delta d_t - 0.2619 ECM_{t-1}$ (3.9912) (3.6477) (-3.5299) (-8.1758)	0,8933	1.9866	0.9128 [0.6335]	5.5305 [0.0630]	13.3690 [0.0998]
NL	$\Delta y_t = 3.3069\Delta k_t + 2.1191\Delta k_{t-1} + 0.8953\Delta k_{t-2} + 0.0971\Delta l_{t-1}$ (6.3711) (5.6906) (3.1207) (3.9035) $+ 0.1468\Delta h_{t-2} + 1.7061\Delta h_{t-3} - 0.1082\Delta d_{t-1} + 0.0615\Delta d_{t-2}$ (4.5438) (4.3054) (-5.2418) (3.1050) $+ 0.0152\Delta d_{t-3} - 0.3592 ECM_{t-1}$ (3.4608) (-7.9430)	0.8861	2.2133	2.6149 [0.2706]	4.0878 [0.1295]	11.7712 [0.54]
65	$\Delta y_t = 1.9415\Delta k_t + 1.5631\Delta k_{t-1} + 0.8682\Delta k_{t-2} + 0.4788\Delta l_t$ (5.9323) (3.5441) (3.6882) (3.5463) $+ 0.4276\Delta l_{t-2} + 0.2646\Delta h_t + 0.0634\Delta d_{t-1} - 0.1293 ECM_{t-1}$ (3.7681) (3.6499) (3.1867) (-6.3868)	0.7258	2.1636	1.3451 [0.5104]	2,3736 [0.3052]	4.8974 [0.7685]
SP	$\Delta y_t = 3.1383\Delta k_t + 1.1341\Delta k_{t-1} + 0.6438\Delta k_{t-2} + 0.1711\Delta l_t$ (7.0649) (5.2017) (3.0516) (3.3203) $+ 0.2222\Delta l_{t-1} + 0.9868\Delta h_t + 0.0302\Delta d_t + 0.0366\Delta d_{t-2}$ (3.4312) (3.7048) (3.4194) (3.0740) $- 0.0757 ECM_{t-1}$ (-6.0164)	0.9213	2.1052	2.9858 [0.2247]	2.3263 [0.3125]	10.2919 [0.3274]

Notes: AT, BE, FI, FR, GE, GR, IE, IT, NL, PT and SP stand for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain respectively.
In the ordinary brackets below the parameter estimates are the corresponding *t*-statistics.
χ^2_N, χ^2_{SC} and χ^2_H are the Jarque-Bera test for normality, the Breusch-Godfrey LM test for second-order serial correlation and the Breusch-Pagan-Godfrey test for heteroskedasticity. In the square brackets, the associated probability values are given.

Table 6. Short-run analysis: Sub-samples

Country		Adjusted R^2	DW Test	χ^2_N	χ^2_{SC}	χ^2_H
AT	1975-1992: $\Delta y_t = 0.2350\Delta y_{t-1} + 0.2100\Delta y_{t-2} + 4.4310\Delta k_t + 2.7001\Delta k_{t-1} +$ (3.1791) (3.1150) (14.4416) (8.8476) $+ 0.7523\Delta l_t + 0.4467\Delta l_{t-1} + 2.8215\Delta h_t + 2.1250\Delta h_{t-1} +$ (8.9557) (3.7418) (4.7908) (4.4687) $+ 0.11251\Delta d_{t-3} - 0.6163 ECM_{t-1}$ (4.3647) (-7.1744)	0.9552	2.4791	1.0758 [0.5840]	4.0321 [0.1332]	9.9306 [0.4466]
	1993-2007: $\Delta y_t = 0.6331\Delta y_{t-2} + 3.2223\Delta k_t + 1.9245\Delta k_{t-1} +$ (7.2458) (11.0950) (6.1336) $+ 0.3524\Delta l_{t-1} + 1.2907\Delta h_{t-1} - 0.03681\Delta d_t$ (6.1884) (4.3695) (-3.7604) $+ 0.0744\Delta d_{t-1} - 0.6222 ECM_{t-1}$ (3.9136) (-8.3849)	0.9487	2.7153	1.1227 [0.5704]	1.5242 [0.4667]	13.5022 [0.2618]
BE	1975-1992: $\Delta y_t = 2.9039\Delta k_t + 1.8710\Delta k_{t.1} + 0.5642\Delta l_t$ `$+ 0.3365.\Delta l_{t-1}$ (5.7798) (3.7391) (3.0507) (3.8698) $+0.8644\Delta h_{t-2} + 0.0438\Delta d_{t-1} - 0.3866 ECM_{t-1}$ (3.6055) (3.8032) (-4.8820)	0.6099	2.1671	1.3153 [0.518]	3.4016 [0.1825]	8.4497 [0.5850]
	1993-2007: $\Delta y_t = 0.5704\Delta y_{t-1} + 0.5094\Delta y_{t.2} + 1.5402\Delta k_t + 0.5273.\Delta l_t$ (5.1835) (5.6005) (3.7479) (7.7830) $+ 0.3748\Delta l_{t-1} + 0.5959\Delta l_{t-2} + 0.7631\Delta h_t - 0.4372 ECM_{t-1}$ (5.8056) (6.1496) (4.2310) (-4.4652) $- 0.3604 ECM_{t-1}$ (-5.1543)	0.8983	2.0832	0.3362 [0.8453]	1.8655 [0.3935]	11.5004 [2430]
FI	1975-1992: $\Delta y_t = 3.9722\Delta k_t + 4.0399\Delta k_{t-1} + 1.9246\Delta k_{t-2} + 0.7448\Delta l_t$ (7.6340) (6.1963) (3.5274) (5.1163) $+ 1.1725\Delta h_t + 0.0495\Delta d_{t-1} - 0.3882 ECM_{t-1}$ (3.1285) (3.5136) (-5.7185)	0.8896	2.1069	2.0943 [0.3509]	2.3967 [0.3017]	5.9478 [0.6531]
	1993-2007: $\Delta y_t = 3.1607\Delta y_{t-1} + 1.7713\Delta y_{t.2} + 4.1208\Delta k_t + 1.8907.\Delta k_{t-1}$ (6.2248) (4.1352) (8.5447) (3.1036) $+1.8907\Delta k_{t-2} + 2.5205\Delta l_t + 1.7825\Delta l_{t-1} + 0.6941\Delta l_{t-2}$ (3. 6954) (5.4790) (5.8310) (3.9308) $+ 4.4774\Delta h_t + 8.3054\Delta h_t + 7.4010\Delta h_{t-1} - 0.1873\Delta d_t$ (5.4720) (4.7005) (4.1237) (-4.2710) $+ 0.1353\Delta d_{t-1} - 0.36091 ECM_{t-1}$ (5.2908) (-6.4588)	0.9898	2.0835	0.0754 [0.9630]	1.5892 [0.4518]	7.2231 [5128]
FR	1975-1992: $\Delta y_t = 1.7115\Delta y_{t-2} + 4.9111\Delta k_{t.1} + 2.1525\Delta l_t + 3.6093.\Delta l_{t-1}$ (4.6774) (7.2721) (3.5040) (3.7694) $+2.5501\Delta l_{t-2} + 4.1244\Delta h_t + 0.2270\Delta d_t - 0.28351 ECM_{t-1}$ (3. 0378) (5.4183) (4.4304) (-5.9611)	0.7222	2.1282	0.6455 [0.7278]	4.0834 [0.1298]	6.4558 [0.5963]
	1993-2007: $\Delta y_t = 6.5227\Delta k_{t-2} + 5.3720\Delta k_{t.2} + 2.6301\Delta l_t + 0.3034.\Delta l_{t-2}$ (4.3702) (3.9422) (4.4518) (3.6961) $+4.9744\Delta h_t + 3.8283\Delta h_{t-1} + 0.07450\Delta d_t - 0.0162\Delta d_{t-1}$ (3. 9117) (3.6829) (4.4610) (-5.2762) $- 0.23301 ECM_{t-1}$ (-6.1699)			0.8183 [0.6642]	4.4779 [0.1066]	10.7231 [0.1512]

Table 6 (continued)

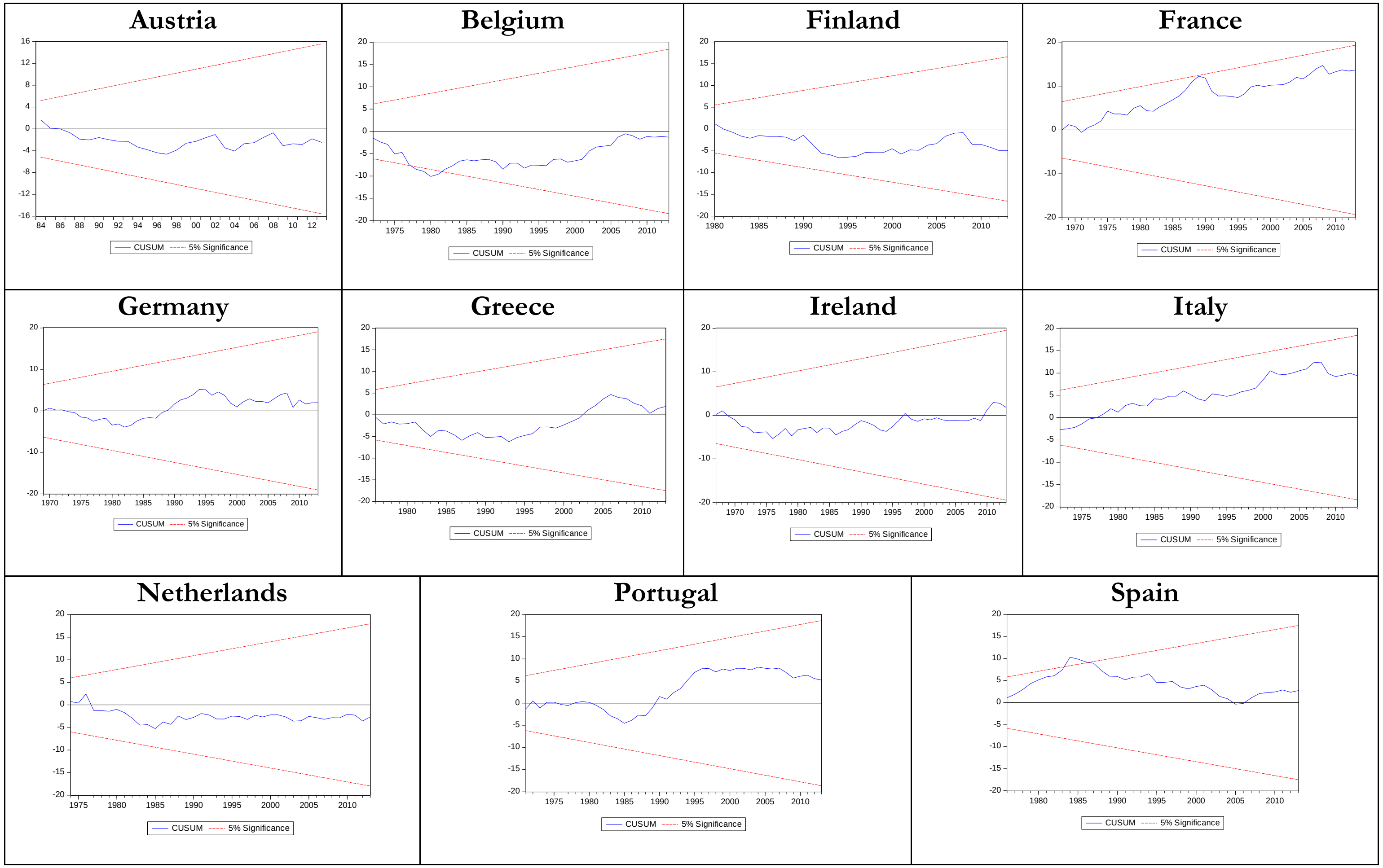
Country		Adjusted R^2	DW Test	χ^2_N	χ^2_{SC}	χ^2_H
GE	1975-1992: $\Delta y_t = 3.7570\Delta k_t + 0.6326\Delta l_{t-1} + 0.8104\Delta l_{t-2} + 7.9377\Delta h_t$ (6.1806) (4.2883) (4.3996) (5.1790) $+ 7.9578\Delta h_{t-1} + 6.8872\Delta h_{t-2} + 0.1029\Delta d_t - 0.5431 ECM_{t-1}$ (5.3513) (4.6265) (5.6831) (-6.3077)	0.9002	2.4239	0.9340 [0.6269]	2.1896 [0.3356]	5.5164 [0.7012]
	1993-2007: $\Delta y_t = 3.3420\Delta k_t + 3.4340\Delta k_{t-1} + .63436\Delta l_t + 0.7948\Delta l_{t-2} +$ (6.8399) (4.2490) (4.8814) (5.1080) $+ 3.6584\Delta h_{t-1} + 0.1892\Delta d_t - 0.5431 ECM_{t-1}$ (5.3755) (4.6265) (-6.1449)	0.7269	2.1528	0.7591 [0.6842]	0.4051 [0.8167]	9.0945 [0.2459]
GR	1975-1992: $\Delta y_t = 5.7859\Delta k_t + 0.5150\Delta l_t + 0.6997\Delta l_{t-2} + 4.3923\Delta h_{t-1}$ (8.0095) (4.2319) (3.3373) (3.7075) $- 0.0016\Delta d_t - 0.3513 ECM_{t-1}$ (-5.2318) (-6.6499)	0.8713	2.1681	0.6310 [0.7294]	1.3139 [0.5184]	1.7407 [0.8837]
	1993-2007: $\Delta y_t = 3.9482\Delta k_t + 2.8034\Delta k_{t-1} + 0.8870\Delta l_{t-2} + 5.6074\Delta h_t$ (4.6276) (3.7518) (3.4782) (3.3317) $+ 3.5789\Delta h_{t-2} + 0.0209\Delta d_t - 0.0384\Delta d_{t-1} - 0.2427 ECM_{t-1}$ (3.3257) (4.3077) (-4.7453) (-7.3991)	0.7556	2.6944	0.8653 [0.6488]	2.0609 {0.3569}	6.2953 [0.2785]
IE	1975-1992: $\Delta y_t = 1.1005\Delta k_{t-1} + 0.4563\Delta l_t + 8.6683\Delta h_{t-1}$ (4.1857) (4.7430) (3.8762) $- 0.2394\Delta d_t - 0.0787 ECM_{t-1}$ (-3.6972) (-6.2426)	0.6302	2.6846	1.2218 [0.5428]	4.0204 [0.1340]	7.1512 [0.4133]
	1993-2007: $\Delta y_t = 2.4412\Delta k_t + 3.1382\Delta k_{t-2} + 0.3288\Delta l_t + 0.5764\Delta l_{t-2}$ (3.6261) (5.9733) (3.8218) (3.5361) $+ 4.6213\Delta h_{t-2} + 0.2269\Delta d_t + 0.3093\Delta d_{t-1} - 0.2496 ECM_{t-1}$ (3.6556) (3.6916) (3.6512) (-7.0424)	0.8441	2.9204	0.2722 [0.8728]	4.4729 [0.1068]	8.3036 [0.2167]
IT	1975-1992: $\Delta y_t = 0.6401\Delta y_{t-1} + 5.0943\Delta k_t + 2.1875\Delta k_{t-2} + 0.7071\Delta l_t$ (5.0920) (7.4728) (5.6433) (4.0363) $+ 0.9676\Delta l_t + 0.6848\Delta h_{t-1} - 0.17120\Delta d_t - 0.5926 ECM_{t-1}$ (3.5787) (2.8963) (4.0578) (-9.3524)	0,9249	2.1785	0.5242 [0.7695]	1.8796 [0.3907]	2.8689 [0.9423]
	1993-2007: $\Delta y_t = 1.3911\Delta k_t + 1.3346\Delta l_t + 1.0485\Delta h_{t-2}$ (4.0109) (6.1877) (4.5483) (4.0363) $+ 0.18020\Delta d_t - 0.3590 ECM_{t-1}$ (3.0609) (-7.7074)	0.7571	2.2826	3.0407 [0.2186]	5.5669 [0.0609]	7.3871 [0.4955]
NL	1975-1992: $\Delta y_t = 4.0912\Delta k_t + 1.6388\Delta k_{t-2} + 0.1009\Delta l_{t-1} + 0.9722\Delta h_{t-1}$ (8.3381) (4.7973) (3.7658) (3.5882) $+ 0.1334\Delta d_{t-1} - 0.1611\Delta d_{t-2} - 0.3553 ECM_{t-1}$ (3.0798) (-4.1641) (-7.5828)	0.8904	2.3691	0.1269 [0.9385]	3.6425` [0.1618]	12.8235 [0.3864]
	1993-2007: $\Delta y_t = 4.2950\Delta k_t + 2.2320\Delta k_{t-2} + 0.4534\Delta l_{t-1} + 1.3217\Delta h_t$ (5.7748) (5.9302) (3.4371) (3.9416) $+ 0.0524\Delta d_t - 0.0018\Delta d_{t-2} - 0.1907 ECM_{t-1}$ (3.8755) (-4.0335) (-6.9055)	0.8974	2.1262	0.6938 [0.7069]	1.4946 [0.4736]	11.3581 [0.3303]

Table 6 (continued)

Country		Adjusted R^2	DW Test	χ^2_N	χ^2_{SC}	χ^2_H
PT	1975-1992: $\Delta y_t = 1.6282\Delta k_{t-1} + 0.5577\Delta l_t + 1.0540\Delta l_{t-2} + 2.9024\Delta h_{t-1}$ (5.0759) (3.4676) (3.7790) (3.1693) $+ 2.4092\Delta h_{t-2} - 0.1639\Delta d_{t-1} - 0.1232 ECM_{t-1}$ (3.3493) (-3.0066) (-6.3284)	0.6612	2.1510	1.0887 [05802]	1.2323 [0.5400]	6.8621 [0.5516]
	1993-2007: $\Delta y_t = 3.3609\Delta k_{t-1} + 2.6908\Delta k_{t-1} + 0.1981\Delta l_t + 1.6141\Delta h_{t-1}$ (4.6086) (4.4837) (3.5701) (3.3398) $- 0.1338\Delta d_t + 0.0335\Delta d_{t-1} - 0.2610 ECM_{t-1}$ (-3.5250) (3.1615) (-6.0434)	0.8363	2,2978	0.0328 [0.9837]	1.6718 [0.4335]	5.5495 [0.6976]
SP	1975-1992: $\Delta y_t = 2.0845\Delta k_t + 1.6611\Delta k_{t-1} + 0.4388\Delta l_t + 0.1853\Delta l_{t-1}$ (4.3561) (4.1395) (3.3720) (3.1882) $+ 0.2098\Delta h_{t-1} + 0.0279\Delta d_t + 0.0845\Delta d_{t-2} - 0.1964 ECM_{t-1}$ (3.2955) (3.7391) (3.4356) (-6.4315)	0.8823	2.1960	1.0587 [0.5890]	2.5897 [0.5799]	7.1813 [0.6182]
	1993-2007: $\Delta y_t = 3.0636\Delta k_t + 2.29241\Delta k_{t-2} + 0.1681\Delta l_t + 0.1379\Delta l_{t-2}$ (7.1281) (6.4499) (3.5240) (3.1085) $+ 1.3498\Delta h_{t-2} - 0.0596\Delta d_t + 0.1897\Delta d_{t-2} - 0.2151 ECM_{t-1}$ (3.3646) (3.3835) (9.0767) (-7.6103)	0.9712	2.4019	0.5265 [0.7686]	0.5286 [0.7678]	5.3493 [0.8090]

Notes: AT, BE, FI, FR, GE, GR, IE, IT, NL, PT and SP stand for Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain respectively.
In the ordinary brackets below the parameter estimates are the corresponding *t*-statistics.
χ^2_N, χ^2_{SC} and χ^2_H are the Jarque-Bera test for normality, the Breusch-Godfrey LM test for second-order serial correlation and the Breusch-Pagan-Godfrey test for heteroskedasticity. In the square brackets, the associated probability values are given.

Figure 1. Plot of cumulative sum of recursive residuals

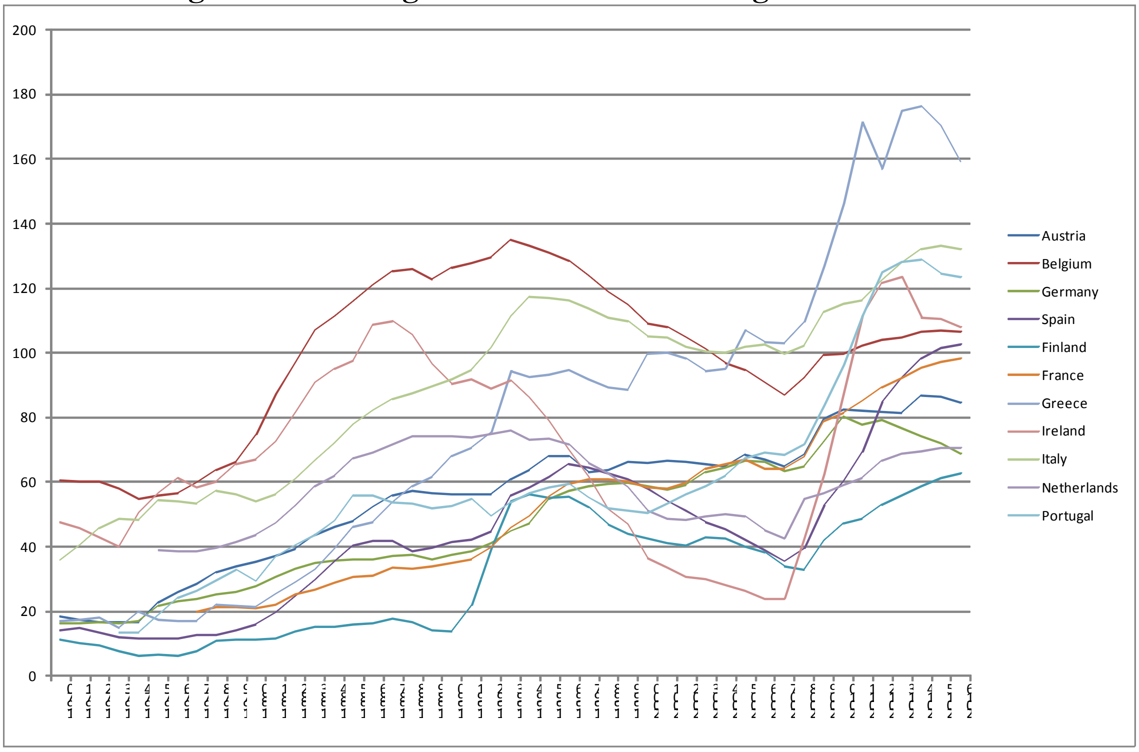


Note: The straight lines represent the critical bounds at a 5% significance level. Belgium: 1977-1982; Spain: 1983-1987.

Figure 2. Plot of cumulative sum of squares of recursive residuals

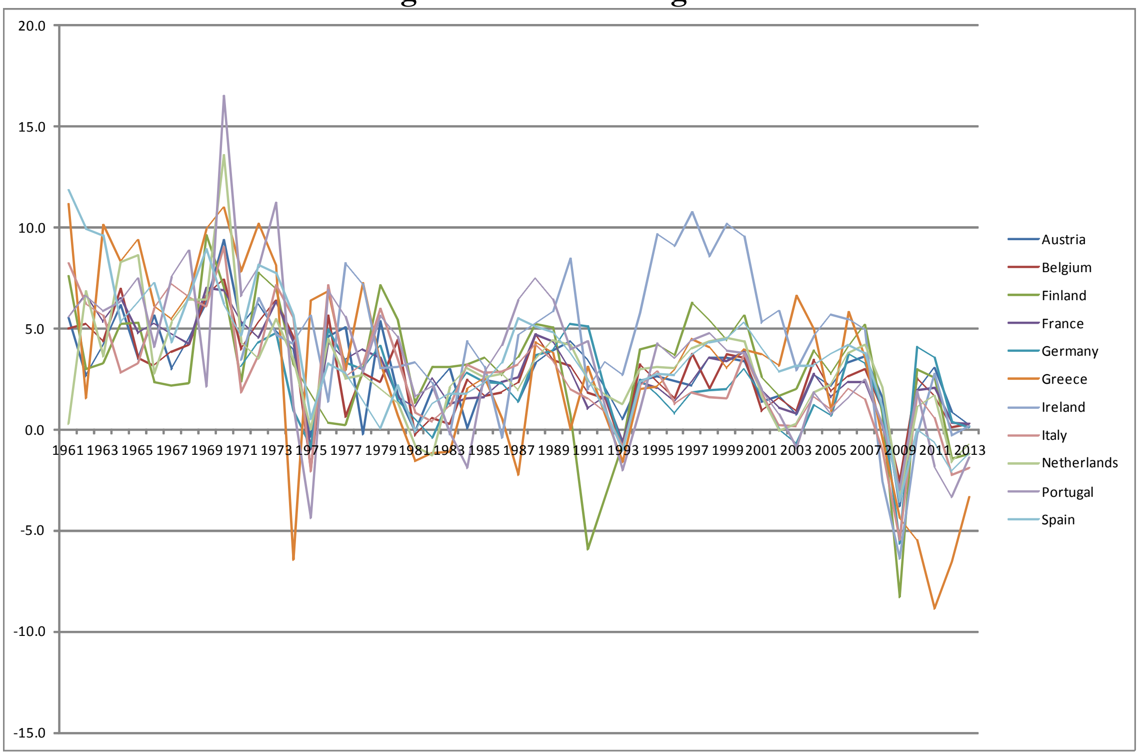
Note: The straight lines represent the critical bounds at a 5% significance level. The Netherlands: 1977-1996; Portugal: 1994-1998.

Figure 3. General government consolidated gross debt/GDP



Source: AMECO (European Commission)

Figure 4. GDP rate of growth



Source: World Development Indicators (World Bank).

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