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# *New empirical evidence on the impact of public debt on economic growth in EMU countries*

# Nueva evidencia empírica sobre el impacto de la deuda pública sobre el crecimiento económico en los países de la UEM

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## Abstract

New empirical evidence is presented on the impact of public debt on economic growth. To that end, we employ the Autoregressive Distributed Lag (ARDL) bounds testing approach using annual data from both central and peripheral countries of the European Economic and Monetary Union (EMU) for the 1961-2015 period. In particular, we allow for different endogenously (data-based) regimes in the parameter relating the public debt variable to the real growth rate. Our results suggest that the impact of public debt on economic growth not only changes across EMU countries, but also over time.

*Keywords:* Public Debt; Economic Growth; Bounds Testing; European Economic and Monetary Union; Peripheral Emu Countries; Central Emu Countries.

## Resumen

Se presentan nuevas evidencias empíricas sobre el impacto de la deuda pública en el crecimiento económico. Para ese fin, empleamos el método de prueba de límites de Retrasos Distribuidos Autorregresivamente (ARDL, por sus siglas en inglés) utilizando datos anuales de los países centrales y periféricos de la Unión Económica y Monetaria Europea (UEM) para el período 1961-2015. En particular, permitimos diferentes regímenes endógenos (basados en datos) en el parámetro que relaciona la variable de deuda pública con la tasa de crecimiento real. Nuestros resultados sugieren que el impacto de la deuda pública en el crecimiento económico no solo cambia entre los países de la UEM, sino también con el tiempo.



*Palabras clave:* Deuda pública; Crecimiento económico; Pruebas de límites; Unión Económica y Monetaria Europea; Países periféricos de la UEM; Países centrales de la UEM.

*JEL Classification Codes:* C22, F33, H63, O40, O52.

## 1. Introduction

The nexus between public debt and economic growth 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 global financial and economic crisis of 2008-2009. In the context of the European and Economic Monetary Union (EMU) countries, although there is widespread agreement about the potentially adverse consequences for EMU economies of their unparalleled levels of public debt, few macroeconomic policy debates have generated as much controversy as the austerity argument [see Alesina and Ardagna (2010), Alesina *et al*. (2015), Guajardo *et al*. (2011) or Jordà and Taylor (2016)]. The debate is hotly contested since economists are far from having reached a consensus.

From an empirical view, studies can be grouped in two generations of papers (see Mitze and Matz, 2015). The "first generation", that include the works by Reinhart and Rogoff (2010), Pattillo *et al*., (2011), Lof and Malinen (2014), Woo and Kumar (2015), Fincke and Greiner (2015) and Jimenez-Rodriguez and Rodríguez-López (2015), among others, predominantly focused on the nonlinear effects in the debt-growth relationship and predicted an inverted U-shape relationship between the two variables (debt begins to harm economic growth when the level of debt exceeds a certain threshold, 90% according to the seminal paper by Reinhart and Rogoff (2010)). However, the analysis presented by a "second generation" of empirical studies [Ghosh et al. (2013), Markus and Rainer (2016), Chudik et al. (2017), Pescatori et al. (2014), Edberhardt and Presbitero (2015) or Gómez-Puig and Sosvilla-Rivero (2018)] goes beyond the nonlinearities in the relationship and focuses in the eventual presence of an heterogeneous debt-growth nexus across countries since now is widely agreed that the effects of public debt on growth may vary depending on country-specific macroeconomic, financial and institutional variables. Nonetheless, although there is also a wide consensus on the fact that heterogeneities in the debt-growth relationship may be found not only across countries but also over time (as long as the country-specific factors are not static, but evolve over time), to our knowledge no empirical study has studied them yet.

In particular, Gómez-Puig and Sosvilla-Rivero (2018) empirically investigated whether the short and the long run impact of public debt on economic growth differed across EMU countries (both central and peripheral) for the 1961-2015 period by means of estimating a production function augmented with a debt stock term and applying the Autoregressive Distributed Lag (ARDL) bounds testing approach. Nonetheless, the empirical results presented in that paper were average values for the entire sample period and did not take into account the possibility that they could change over time if a structural break occurred.

Therefore, the objective of this paper is to explore the possibility of multiple structural changes in the parameter relating the public debt variable to the real growth rate, therefore allowing for different endogenously (data-based) regimes and identifying heterogeneities in both the temporal and country impact of public debt on economic performance. This is a very relevant topic since a time-varying debt-growth relationship in line with the evolution of the country-specific factors (macroeconomic financial or institutional) will imply that rigid criteria will not be advisable when addressing the necessary adjustments. In addition, our analysis represents an important contribution to the existing literature since, as far as we know, this is the first paper that analyses the heterogeneities in the debt-growth nexus, not only across countries, but also over time.

The rest of the paper is organized as follows. Section 2 discusses the analytical framework and the econometric methodology. Section 3 describes our data. Section 4 present the empirical results. Finally, Section 5 provides some concluding remarks.

## 2. Analytical framework and econometric methodology

Departing from the previous literature that analysed the relationship between debt and economic growth estimating an equation based on the growth literature (e.g., Barro and Sala-i-Martin, 2004) augmented by public debt, Gómez-Puig and Sosvilla-Rivero (2018) follows Edberhardt and Presbitero (2015) and explore the debt–growth nexus using an aggregate production function in which public debt is included as a separate factor of production:

$$Y_t = AF(K_t, L_t, H_t, D_t) \tag{1}$$

where $Y$ is the level of output, $A$ is an index of technological progress, $K$ is the stock of physical capital, $L$ is the labour input, $H$ is the human capital, and $D$ is the stock of public debt[1].

Regarding the inclusion of the public debt stock as an input in an aggregated production function[2], both Brauninger (2003) and Greiner (2007) present and

[1] We do not consider the stock of technological capital (estimated using data on R&D) because we do not have data for the entire sample period, so the results should be taken with caution since this omitted variable could be potentially correlated with the stock of public debt. Nevertheless, the data used for the stock of physical capital include computer software and intangible fixed assets (Eurostat, 1996).

[2] We are grateful to an anonymous referee for suggesting a justification of the use of this approach.

analyse an endogenous growth model using a production function with public debt. This inclusion could be justified on the basis that debt financing of public investment creates incentives for providing public infrastructure projects that contribute to growth in demand and to increase productivity (see, e. g., Kopits, 2001)[3]. Since public services lead to external economies and, accordingly, lower production costs, we can state, following Arrow and Kurtz (1970), that production in the private sector would be directly affected by those goods and services provided by the public sector. Indeed, some authors like Aschauer (1989a,b,c) and Bajo-Rubio and Sosvilla-Rivero (1993) have forcefully argued for a direct and sizeable effect of public sector capital accumulation on private sector productivity and performance[4]. Nevertheless, as debt-to-growth ratio increases, it makes creditors to demand for higher interest rates to mitigate the default risk. Thus, this may lead to a rise in the cost of financing, which could limit investment and production (Greenlaw et al., 2013). Similarly, results in Huang*et al*. (2018) indicate that the relationship between public debt and investment is likely to be causal and that public debt crowds out corporate investment by tightening credit constraints.

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

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

so that, after taking logs and denominating by a small letter the log of its corresponding capital letter, we obtain

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

As can be seen, equation (3) postulates a technical long-run relationship between (the log of) the level of production ($y_t$), (the log of) the stock of physical capital ($k_t$), (the log of) the labour employed ($l_t$), (the log of) the human capital ($h_t$) and (the log of) the stock of public debt ($d_t$).

Equation (3) can be estimated from sufficiently long time series by cointegration econometric techniques. So, we make use of the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration proposed by Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001).

[3] Debt financing of public investment is further considered to be in line with the benefit principle of taxation or (as Musgrave (1939) calls it) the "pay as you use principle", and thus is consistent with a fair intergenerational distribution (see Yakita, 1994).

[4] The special treatment of public investment in the Stability and Growth Pact is to some extent motivated by fear that the EMU fiscal rules are likely to depress the volume of growth-enhancing public investment and thus to reduce economic performance in the future (see, e. g., Buiter, 2001; Balassone and Franco, 2000).

The application of the ARDL approach to cointegration involves estimating the following unrestricted error correction model (UECM)

$$\Delta y_t = \beta + \sum_{i=1}^{p}\gamma_i \Delta y_{t-i} + \sum_{i=1}^{q_1}\omega_i \Delta k_{t-i} + \sum_{i=1}^{q_2}\varphi_i \Delta l_{t-i} + \sum_{i=1}^{q_3}\upsilon_i \Delta h_{t-i} + \sum_{i=1}^{q_4}\phi_i \Delta d_{t-i} + \\ + \lambda_1 y_{t-1} + \lambda_2 k_{t-1} + \lambda_3 l_{t-1} + \lambda_4 h_{t-1} + \lambda_5 d_{t-1} + \varepsilon_t \quad (4)$$

where Δ denotes the first difference operator, β is the drift component, and $\varepsilon_t$ is assumed to be a white noise process. Note that $p$ is the number of lags of the dependent variable and $q_i$ is the number of lags of the *i-th* explanatory variable. The optimal lag structure of the first differenced regression (4) is selected by the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) to simultaneously correct for residual serial correlation and the problem of endogenous regressors (Pesaran and Shin, 1999, p. 386). In order to determine the existence of a 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. $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$), and then a *t-statistic* is used to test the individual significance of the lagged dependent variable in levels (i. e. $\lambda_1 = 0$).

Based on two sets of critical values: I(0) and I(1) (Pesaran, Shin, and Smith 2001), if the calculated *F*-or *t*-statistics exceed the upper bound I(1), we conclude in favour of a long-run relationship, regardless of the order of integration. However, if these statistics are below the lower bound I(0), the null hypothesis of no cointegration cannot be rejected. Finally, if the calculated *F*- and *t*-statistics fall between the lower and the upper bound, the results are inconclusive.

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:

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

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

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

## 3. Data

We use annual data covering the period 1961-2015 (i.e., a total of 54 annual observations) for eleven EMU countries: both central (Austria, Belgium, Finland, France, Germany and the Netherlands) and peripheral member states (Greece, Ireland, Italy, Portugal and Spain).

To maintain as much homogeneity as possible for a sample of 11 countries over the course of five decades, our primary source is the European Commission´s AMECO database[5]. 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, net capital stock and public debt (all expressed at 2010 market prices) for $Y$, $K$ and $D$, as well as civilian employment and life expectancy at birth for $L$ and $H$[6]. The precise definitions and sources of the variables are given in Appendix 1.

## 4. Empirical results

After checking that all variables can be treated as first-difference stationary[7], Gómez-Puig and Sosvilla-Rivero (2018) estimate an ARDL representation with 4 lags selected using the AIC and SBC information criteria and offer evidence on the existence of a long-run relation between the output and its components, as suggested by equation (3). In particular, they find that the long-term effect of debt on economic performance registers a negative value in all EMU countries, but its magnitude differs significantly across countries. While comparatively high impacts are estimated in the case of France (-0.544), Portugal (-0.354), Spain (-0.336), and Austria (-0.129), in the rest of countries, although negative, the magnitude is very small with values close to zero. Ireland (-0.049), Finland (-0.049) and Germany (-0.040) are the countries with the lowest negative impact.

Regarding the short-term dynamics, Gómez-Puig and Sosvilla-Rivero (2018) estimate an error-correction model associated with the long-run relationship, detecting a heterogeneous short-run impact of debt on economic performance. Interestingly, they document that even though there is a long- run negative impact in Portugal and Spain, the short-term effect is positive (0.063 and 0.067), although quite small. In the cases of Greece, Ireland and Italy, they find that an increase in public debt exert a negative effect on GDP, not only in the long run but in the short run as well. Among central EMU countries, their

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

[6] As explained in Appendix 1, following Sachs and Warner (1997), we use life expectancy at birth as the human-capital proxy.

[7] These results (not shown here in order to save space, but available from the authors upon request) are based on both Augmented Dickey-Fuller (ADF) tests ((where the null is a unit root against the alternative of stationary process) and on the Kwiatkowski et al. (1992) (KPSS) tests (where the null is a stationary process against the alternative of a unit root).

results suggest that in Germany and Finland the effect of public debt on GDP is positive in the short run (0.375 and 0.059) despite the negative (though very small) effect in the long run. Finally, in the case of Austria, Belgium, France and the Netherlands their results suggest that public debt has a negative impact on economic activity in both the short and the long run.

Nevertheless, the empirical results presented in Gómez-Puig and Sosvilla-Rivero (2018) are average values for the entire sample period (1961-2015) and do not take into account the possibility that they could change over time if a structural break occurred. Therefore, the objective of the present paper is to explore the possibility of multiple structural changes in the parameter relating the public debt variable to the real growth rate ($\psi_t$) in equation (6) by using the Bai and Perron (1998) test[8]. The results (not shown here to save space, but available from the authors upon request) seem to suggest strongly that there are two structural breaks in each of the estimated models. The detected break dates and the associated levels of public debt-to-GDP ratio are displayed in Table 1.

Table 1: Results of the structural changes test in the coefficient of the public debt

| | AT | BE | FI | FR | GE | GR | IE | IT | NL | PT | SP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Structural break 1* | 1987 (58%) | 1977 (60%) | 1991 (22%) | 1986 (31%) | 1983 (39%) | 1979 (23%) | 1988 (107%) | 1976 (56%) | 1978 (41%) | 1986 (57%) | 1993 (52%) |
| *Structural break 2* | 2007 (60%) | 2005 (92%) | 2007 (35%) | 2005 (67%) | 2008 (67%) | 2008 (113%) | 2007 (25%) | 2007 (106%) | 2008 (58%) | 2003 (56%) | 2009 (54%) |

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, the associated levels of public debt-to-GDP ratio are given.

As can be seen, in all the countries under study, the first break point occurred before 1999 (i.e., before the beginning of the EMU). It is located in the seventies in four countries: (1) Belgium , – with the starting of an interest snowball from 1977 that led to one of the largest increases in debt-to-GDP ratios in advanced economies (Mauro and Zilinsky, 2016), (2) Greece, when this country entered a period of stagflation, caused by the second oil shock of 1979 (Alogoskoufis, 2012), (3) Italy, after a currency crisis in a period of severe political instability (Lubitz, 1978), and (4) the Netherlands, following a major change in economic policy (OECD, 1979). It occurred in the eighties in five economies: (1) Austria, around the introduction of measures to deal with serious structural problems in public finances (Katterl and Köhler-

[8] Bai and Perron (1998) consider the estimation of multiple structural shifts in a linear model estimated by least squares. They propose some tests for structural changes and a selection procedure based on a sequence of tests to estimate consistently both the number of breaks and the induced structural regimes in a linear model. We follow their recommendation and use a trimming region of 15%. We allow the system to search for a maximum of five breaks, which is the largest permissible number according to the Bai and Perron procedure.

Töglhofer, 2005), (2) France, after a period of fiscal consolidation that resulted in a stabilization of the debt-to-GDP ratio (Corsetti and Roubini, 1991), (3) Germany, in the aftermath of the recession of 1983-1985 which introduced stagflation (Siebert, 2005), (4) Ireland, in a context of sustained real GDP expansion that lulled policymakers into a false sense of security regarding the sustainability of the revenues from cyclically sensitive taxes (Honohan, 2009), and (5) Portugal, marked by a second IMF-supported stabilization program, 1983–1985. Finally, it took place in the nineties in the other two EMU countries in our sample: (1) Finland, after experiencing a banking crisis in 1991 that worsened the fiscal balance (Reinhart, 2009), and (2) Spain, coinciding with a severe economic crisis in 1993. Moreover, it is noticeable that the public debt-to-GDP ratio associated to the first break point surpasses the level of 60% only in Ireland (107%).

Regarding the second break point, in all cases it took place after the implementation of the common currency and in eight out of the 11 cases under study it occurred in 2007 or later, coinciding with the global financial and economic crisis. Specifically, it took place in 2007 (coinciding with the subprime crisis in the United States) in Austria, Finland, Ireland and Italy; in 2008 (when Lehman Brothers collapsed) in Germany, Greece and the Netherlands; and in 2009 (coinciding with the beginning of the EMU sovereign crisis) in Spain[9]. However, in all countries but Spain, the second break date occurred before the economic recession reached its trough during the third regime, which pushed public debt up to unprecedented levels. Therefore, it can be observed that the associated debt-to-GDP ratio clearly increases in the second break point compared with the first one, presenting values of above 60% in 6 out of the 11 countries under study. Specifically, it occurs at ratios marginally above that value in Austria, Germany and France; slightly above 90% in Belgium and above 100% in Italy and Greece.

If we focus on peripheral EMU countries, it can be observed that whilst in Spain and Portugal the public debt-to-GDP ratios associated with the two break dates are very similar (55% on average), in the other three countries they diverge significantly. As can be seen, in Greece the public debt-to-GDP ratio increases from 23% in the first break point (1979) to 113% in the second one (2008). A similar pattern is found in Italy, where it rises from 56% in 1976 to 106% in 2007. Nonetheless, the behaviour in Ireland is completely different: the ratio was 107% at the first break point (1988) and decreased to 25% at the second one (2007), indicating that the substantial debt accumulation in 2007-2008 was preceded by a huge deleverage period in that country.

Next, we utilize this information and form three regimes for each country. The idea is to re-estimate the regression model including a dummy variable that incorporates the detected breakpoints and gauge whether structural breaks have disturbed the effect of public debt on the real growth rate:

[9] In 2009 Spanish public deficit reached a historical peak of 11.0% of GDP.

$$\Delta y_t = \sum_{i=1}^{p}\theta_i \Delta y_{t-1} + \sum_{i=1}^{q_1}\varpi_i \Delta k_{t-1} + \sum_{i=1}^{q_2}\pi_i \Delta l_{t-1} + \sum_{i=1}^{q_3}\tau_i \Delta h_{t-1}$$
$$+\sum_{i=1}^{q_4}\psi_i^1 \Delta d_{t-1} + \sum_{i=1}^{q_4}\psi_i^2 \Delta d_{t-1} D1_t + \sum_{i=1}^{q_4}\psi_i^3 \Delta d_{t-1} D2_t + \eta ECM_{t-1} \quad (7)$$

where $D1_t$ is a dummy variable taking value 0 from 1961 until $T_1$-1 and 1 between $T_1$ and $T_2$-1 and $D2_t$ is a dummy variable taking value 0 from 1961 until $T_2$-1 and 1 between $T_2$ and $T$, being $T_1$ and $T_2$ the detected break dates.

From the significant coefficients estimated using equation (7), following Hendry (1995)'s suggestion, we can compute for every country the short-term impact of debt on economic performance during each of the three regimes as:

$$\text{short-term effects in regime } j = \sum_{i=1}^{q_4}\psi_i^j / (1-\sum_{i=1}^{p}\theta_i),\ j = 1,2,3 \quad (8)$$

The full estimations results are reported in Appendix 2, while the estimated short-term effects are presented in Table 2. As can be seen, we find very different results across central and peripheral countries.

TABLE 2: SHORT-RUN ANALYSIS WITH STRUCTURAL BREAKS

| *Central EMU countries* | *Short-term* | *Regime 1* | *Regime 2* | *Regime 3* |
|---|---|---|---|---|
| Austria | -0.331*<br>(-2.994)<br>[1961-2015] | -0.119*<br>(-3.393)<br>[1961-1986] | -0.158*<br>(-3-011)<br>[1987-2006] | -0.074*<br>(-3.082)<br>[2007-2015] |
| Belgium | -0.186**<br>(-4.346)<br>[1961-2015] | -0.295**<br>(-3.945)<br>[1961-1976] | -0.271**<br>(-2.740)<br>[1977-2004] | -0.376*<br>(-3.842)<br>[2005-2015] |
| Finland | 0.059*<br>(4.950)<br>[1961-2015] | 0.074*<br>(3.6448)<br>[1961-1990] | -0.036*<br>(-3.067)<br>[1991-2006] | -0.037*<br>(-3.741)<br>[2007-2015] |
| France | -0.054*<br>(-3.252)<br>[1961-2015] | -0.062*<br>(-3.149)<br>[1961-1985] | -0.030*<br>(-2.951)<br>[1986-2004] | -0.014*<br>(-3.287)<br>[2005-2015] |
| Germany | 0.375*<br>(3.882)<br>[1961-2015] | 0.308*<br>(4.117)<br>[1961-1982] | -0.106*<br>(-3.696)<br>[1983-2007] | -0.044*<br>(-4.358)<br>[2008-2015] |
| Netherlands | -0.031*<br>(-3.936)<br>[1961-2015] | -0.027*<br>(-3.643)<br>[1961-1977] | -0.008*<br>(-3.200)<br>[1978-2007] | -0.037*<br>(-2.918)<br>[2008-2015] |

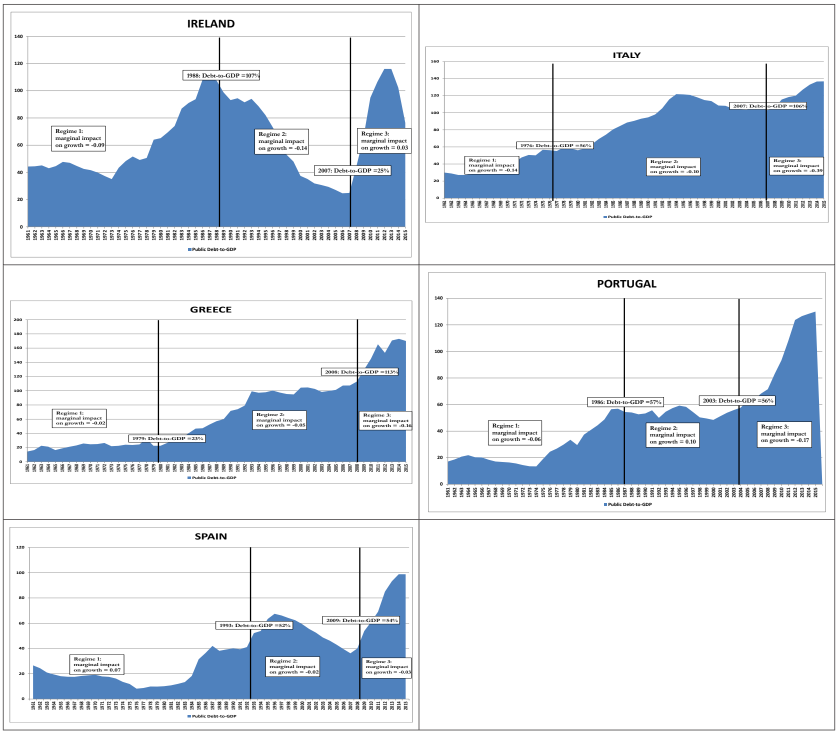
| *Peripheral EMU countries* | *Short-term* | *Regime 1* | *Regime 2* | *Regime 3* |
|---|---|---|---|---|
| Greece | -0.195*<br>(-3.732)<br>[1961-2015] | -0.017*<br>(-3.874)<br>[1961-1978] | -0.052*<br>(-3.701)<br>[1979-2007] | -0.255*<br>(-2.933)<br>[2008-2015] |
| Ireland | -0.077*<br>(-3.902)<br>[1961-2015] | -0.090**<br>(-2.740)<br>[1961-1987] | -0.137*<br>(-3.624)<br>[1988-2006] | 0.031*<br>(-2.870)<br>[2007-2015] |
| Italy | -0.143*<br>(-3.714)<br>[1961-2015] | -0.143*<br>(-3.526)<br>[1961-1975] | -0.098*<br>(-3-702)<br>[1976-2006] | -0.391*<br>(-3.689)<br>[2007-2015] |
| Portugal | 0.063*<br>(3.187)<br>[1961-2015] | -0.056*<br>(3.160)<br>[1961-1985] | 0.097**<br>(2.813)<br>[1986-2002] | -0.174*<br>(-2.971)<br>[2003-2015] |
| Spain | 0.067*<br>(2.882)<br>[1961-2015] | 0.072*<br>(2.997)<br>[1961-1992] | -0.016**<br>(-2.805)<br>[1993-2008] | -0.029*<br>(-2.945)<br>[2009-2015] |

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, the corresponding *t*-statistics are shown.
In the square brackets, the sample period for each regime is given.
The short-run effects of public debt on economic growth are calculated using equations (7) and (8)
* and ** denote statistical significance at the 1% and 5% level respectively.

Regarding central EMU countries, with the exception of France, in countries where debt had a negative short-run effect on growth (Austria, Belgium, and the Netherlands), these inverse relationships between debt and growth seem to strengthen throughout the detected regimes. However, in Germany and Finland (where debt had a positive short-run effect on growth), we only detect a positive relationship between these two variables during the first regime (i.e., before the first break point). Subsequently, from 1983 and 1991 onwards, debt also exerts a negative effect on growth in Germany and Finland respectively.

Interestingly, in peripheral EMU countries, although we found that the short-run effect was positive in Portugal and Spain, a positive relationship between debt and the real growth rate during the first regime is only found in the Spanish case. However, it is noticeable that in this economy, although the relationship changes to negative from 1993 until the end of the sample, its magnitude is very small (-0.016 and -0.029 in the second and third regime, respectively). In the case of Portugal, we find a temporary positive coefficient after the first detected break (during the 1986-2002 period), followed by a further negative coefficient after the second break, reinforcing the inverse association between the variables under study from then on. Moreover, a small positive relationship (0.031) between debt and growth is also found in Ireland during the third regime (2007-2015) where, after an important deleveraging process, the debt-to-GDP ratio reached a value of 25% in 2007. Finally, in the other two peripheral EMU countries (Italy and Greece), we find a negative relationship between the two examined variables not only in the short-term, but throughout the three examined regimes as well. This behaviour could be related to the fact that these two countries present the highest average debt-to-GDP ratio during the 1961-2015 period (75% and 69% respectively).

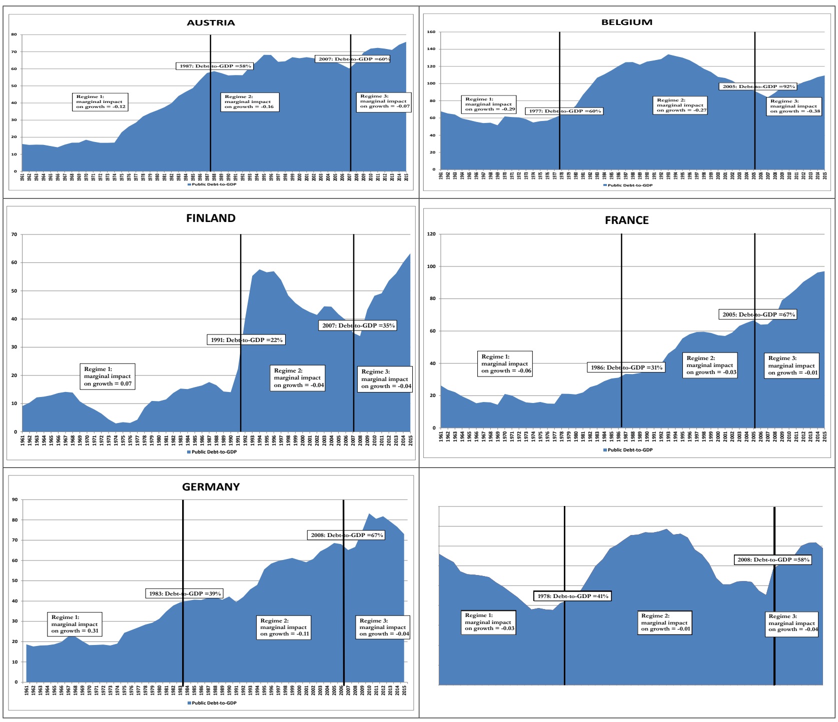
Figure 1a: Debt-growth relationship in peripheral EMU countries




Figures 1a and 1b summarize the main results for peripheral and central EMU countries respectively. Specifically, they present for each EMU country: (1) the two break points with the associated debt-to-GDP ratio and (2) the evolution of the marginal impact of sovereign debt ratio on economic growth in the three regimes into which the sample period is split.

Figure 1a shows the existence of a positive relationship between the public debt-to-GDP ratio and economic growth in some sub-periods in three peripheral EMU countries: Spain (from 1961 until 1992), Portugal (from 1986 until 2002), and Ireland (between 2007 and 2015). Therefore, with the exception of Ireland, in the other two peripheral EMU countries (which also registered a positive short-run effect), the relationship between public debt and economic growth only becomes negative from a debt-to-GDP ratio between 50% and 60%. Moreover, again with the exception of Ireland, the highest detrimental marginal impact of public debt on peripheral countries' economic performance takes place after the second break point (mainly from 2007 to 2009, coinciding with the global financial crisis), with debt-to-GDP ratios that range from 55% (Spain and Portugal) to slightly above 100% (Italy and Greece), being Spain the peripheral country where the negative impact is lower during the crisis episode.

Figure 1b: Debt-growth relationship in central EMU countries




Source: AMECO, IMF and own estimates.

The highest negative marginal impact also takes place after the second break date in three out of the six central EMU countries (see Figure 1b). In Finland and the Netherlands, it occurs from 2007-2008 (with a debt-to-GDP level that ranges from 35% to 58%), while in Belgium it takes place from 2005 with debt-to-GDP levels above 90%.

Therefore, our results seem to suggest that the debt-to-GDP ratio at which public debt exerts the strongest negative impact on economic growth, not only changes across EMU countries, but also over time. In seven out of eleven countries, the negative impact is especially high in times of distress, but the associated debt ratio clearly differs across countries. Whilst in some countries it takes place at low ratios (e.g., at 35% in Finland), in others it occurs at very high values (90% in Belgium and above 100% in Italy and Greece). In addition, the highest negative marginal impact also differs across EMU countries. The maximum negative values are observed in Italy and Belgium (-0.391 and -0.376), whilst the minimum is registered in Spain (-0.029).

## 5. Concluding remarks

Despite the severe sovereign debt crisis in the EMU, few papers have examined the relationship between debt and growth for member states. The limited body of literature available focuses on the existence of nonlinearities in the relationship and lends support to the presence of a common debt threshold across EMU countries. However, to our knowledge, the empirical work that analyses the eventual heterogeneities in the relationship (both across countries and over time) is still very scarce, even though they are acknowledged by the literature. Gómez-Puig and Sosvilla-Rivero (2018) is one exception, although the analysis in that paper is focused in the different incidence of debt accumulation on economic growth taking into account the particular characteristics of each EMU economy, but it disregards whether the effects may also differ depending on the time horizon if a structural break occurred. So, the present study complements the paper of Gómez-Puig and Sosvilla-Rivero (2018) since heterogeneities in the debt-growth relationship are not only examined across countries, but also over time.

To that end, as in Gómez-Puig and Sosvilla-Rivero (2018), in this paper we use time series analyses to estimate, for each country in the sample, a log-linearized Cobb–Douglas production function augmented with a debt stock term, by means of the ARDL testing approach to cointegration. However, the analysis is extended by allowing the coefficient estimates capturing in the short run dynamics the effect of public debt variable to differ before and after two endogenously (data-based) identified structural breaks. Our results indicate that debt exerts a positive effect on growth in the first regime in Finland, Germany and Spain (from 1961 until 1990, 1982 and 1992 respectively); whilst a positive relationship is found in the second regime in the case of Portugal (between 1986 and 2002). In all cases, the positive relationship between a debt increase and economic growth is found when the indebtedness level is either low or moderate (i.e., in sustainable debt periods). Moreover, within EMU peripheral countries, Spain is the one that presents the lowest negative relationship between debt and growth during the distress episode (-0.029).

Our findings have significant policy implications, since they suggest that the impact of public debt on economic growth changes both across EMU countries and over time, implying that rigid and uniform criteria are not advisable when addressing the necessary adjustments. Specifically, our findings suggest that the pace of fiscal adjustment should be adapted to the evolving characteristics of each country over time. Therefore, the speed of progress toward a specified fiscal target is an open question, although gradualism can be a powerful tool in helping achieve the objectives of a broader growth strategy (Dewatripont and Roland 1995). In any case, in our view, adjustment programmes should be accompanied by structural reforms able to increase the adjustment capacity or the potential GDP in euro area countries.

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## Founding

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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, total economy | AMECO |
| Accumulated 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 |

Appendix 2: Short-run estimations results with structural breaks

| | AT | BE | FI | FR | GE | GR | IE | IT | NL | PT | SP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta y_{t-1}$ | 0.336* (2.955) | | | | 0.134* (3.510) | | | 0.301 (4.016) | | | |
| $\Delta yt_{-2}$ | 0.263** (2.714) | | | | | | | 0.191 (3.828) | | | |
| $\Delta k_t$ | 3.296* (6.242) | 2.769* (6.349) | 3.987* (5.979) | 0.538* (4.613) | 4.673* (6.649) | 3.948* (4.990) | | 5.324 (7.021) | 3.335 (6.786) | 1.788* (5.511) | 3.159* (7.199) |
| $\Delta k_{t-1}$ | 1.432* (2. 870) | 1.923* (4.486) | 4.308* (6.226) | | 3.409* (4.082) | 2.159* (4.332) | 1.688* (4.550) | 3.388* (6.658) | 2.154* (4.833) | 1.474* (3.458) | 1.129* (5.377) |
| $\Delta k_{t-2}$ | | | 2.113* (3.787) | | | | | | 0.918* (3.167) | 0.928* (3.625) | 0.699* (3.064) |
| $\Delta l_t$ | 0.575* (4.211) | 0.592* (3.787) | 0.697* (4.256) | 2.706* (6.613) | 0.619* (3.741) | 0.379* (3.762) | 0.557* (4.890) | 0.083* (3.578) | | 0.448* (3.256) | 0.200* (3.018) |
| $\Delta l_{t-1}$ | | | | | | | | | 0.105* (3.572) | | 0.226* (3.367) |
| $\Delta l_{t-2}$ | | | 0.103* (3.002) | 1.330* (3.047) | | | | | | 0.507* (3.240) | |
| $\Delta h_t$ | | | 1.299* (3.349) | | 0.270* (3.741) | | | | | 0.293* (3.621) | 0.990* (3.317) |
| $\Delta h_{t-1}$ | 1.843** (2.834) | 1.681* (2.998) | | 2.701* (3.286) | | | 4.783* (3.758 | | | | |
| $\Delta h_{t-2}$ | | 1.426** (2.672) | | | | | | | 0.186* (3.808) | | |
| $\Delta h_{t-3}$ | | 0.822** (2.655) | | | | | | 0.779* (3.580) | 1.730* (3.715) | | |
| $\Delta d_t$ | -0.131* (-3.634) | -0.295* (-3.945) | | | | | -0.090* (-3.740) | -0.077* (-3.431) | | | 0.023* (3.317) |
| $\Delta d_t D1_t$ | 0.0450* (2.964) | -0.271* (-3.892) | | | | | -0.137* (-3.627) | -0.052* (-3.524) | | | 0.031* (2.867) |
| $\Delta d_t D2_t$ | -0.078* (-3.182) | -0.376* (-3.892) | | | | | 0.031* (2.870) | -0.210* (-2.991) | | | -0.019* (-3.159) |
| $\Delta d_{t-1}$ | 0.148* (3.695) | | 0.074* (3.648) | -0.062* (-3.148) | -0.093* (-3.359) | -0.017* (-3.874) | | | -0.090* (-4.751) | -0.056* (-3.160) | |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta d_{t-1}D1_t$ | -0.090* (-3.124) | | -0.036* (-3.067) | -0.030* (-2.951) | -0.039* (-3.960) | -0.052* (-3.701) | | | -0.022* (-3.777) | 0.097** (2.813) | |
| $\Delta d_{t-1}D2_t$ | -0.021* (-2.903) | | -0.0365* (-3.741) | -0.014* (-3.287) | -0.044* (-3.665) | -0.255* (-2.933) | | | -0.014* (-2.999) | -0.174* (-2.971) | |
| $\Delta d_{t-2}$ | | | | | | | | | 0.048* (3.176) | | 0.048* (2.862) |
| $\Delta d_{t-2}D1_t$ | | | | | | | | | -0.009* (-2.945) | | -0.047** (2.744) |
| $\Delta d_{t-2}D2_t$ | | | | | | | | | -0.022** (2.831) | | -0.011** (-2.731) |
| $\Delta d_{t-3}$ | -0.065* (-2.849) | | | | | | | | 0.015* (3.004) | | |
| $\Delta d_{t-3}D1_t$ | -0.023* (-2.944) | | | | | | | | 0.024* (2.878) | | |
| $\Delta d_{t-3}D2_t$ | 0.069* (3.161) | | | | | | | | -0.001* (-2.925) | | |
| $ECM_{t-1}$ | -0.529* (-6.984) | -0.391* (-4.461) | -0.563* (-4.915) | -0.611* (-4.886) | -0.548* (-5.892) | -0.176* (-5.219) | -0.281* (-6.973) | -0.255* (-8.182) | -0.364* (-5.589) | -0.139* (-6.988) | -0.279* (-3.638) |
| Adjusted $R^2$ | 0.837 | 0.734 | 0.897 | 0.650 | 0.868 | 0.841 | 0.673 | 0.904 | 0.892 | 0.746 | 0.849 |
| DW Test | 2.291 | 2.143 | 2.151 | 2.110 | 2.029 | 2.011 | 2.018 | 2.121 | 2.205 | 2.119 | 2.132 |
| $\chi^2_N$ | 0.816 [0.665] | 0.734 [0.641] | 1.466 [0.480] | 1.058 [0.589] | 1.199 [0.430] | 1.844 [0.398] | 0.483 [0.786] | 1.146 [0.564] | 3.036 [0.219] | 1.513 [0.469] | 1.381 [0.471] |
| $\chi^2_{SC}$ | 1.048 [0.368] | 1.173 [0.415] | 0.847 [0.439] | 1.400 [0.258] | 2.080 [0.137] | 0.493 [0.671] | 1.946 [0.155] | 1.998 [0.150] | 4.400 [0.145] | 0.050 [0.9512] | 0.028 [0.973] |
| $\chi^2_H$ | 14.485 [0.563] | 13.785 [0.183] | 9.255 [0.351] | 12.832 [0.145] | 8.419 [0.394] | 6.783 [0.452] | 9.004 [0.252] | 10.261 [0.418] | 20.247 [0.209] | 8.338 [0.569] | 10.122 [0.684 |

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, the corresponding *t*-statistics are shown.

The short-run effects of public debt are calculated using equation (7)

* and ** denote statistical significance at the 1% and 5% level, respectively.

$\chi^2_N$, $\chi^2_{SC}$ and $\chi^2_H$ 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.