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Debt and economic growth: Is there any causal effect? An empirical analysis with structural breaks and Granger causality for Greece

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Abstract. *During the last decade Greece has faced many economic problems. The economy is teetering on the brink of bankruptcy and the debt deepens. In this paper we will examine whether the debt is promoting economic growth in Greece. We use time series data from 1980 to 2010. The data is fitted into the regression equation using econometric techniques such as Phillips – Perron, Augment Dickey – Fuller and KPSS. We are testing the variables with techniques such as Zivot Andrew's, Perron's and Bai Perron's tests to find any structural breaks. Then we are testing to see if there is any causal effect in our model with Granger causality test. The results reveal that there are structural breaks in the economy of Greece but no causality between the variables.*

Keywords: economic growth, public debt, structural breaks, Bai Perron test, Granger causality.

JEL Classification: A10, C32, N15.
REL Classification: 8E.

1. Introduction

During the recent decade, many developing countries are facing economic problems and high levels of indebtedness. Greece is one of the countries of the European Union (E.U) which facing major economic problems. There is no doubt that it is at a very critical juncture of its recent history and the danger of bankruptcy is very close.

2. Literature review

There is a wide body of literature, analyzing the relationship between debt and economic growth in both developed and developing countries. Eaton (1993) found that for developing countries it is expected that the marginal product should be higher than the world interest rate. Because of that such countries would benefit from external borrowing. Afxentiou (1993) argues that high levels of debt have a negative effect on economic growth.

According to Krugman (1988) "debt overhang" defined as the situation in which the expected repayment on external debt falls short of the contractual value of debt, and therefore expected debt service is likely to be an increasing function of the country's output level. In many empirical research the negative effect between external debt and economic growth is attributed to "debt overhang"

Many researchers (e.g. Savvides (1992), IMF (1989) and Greene and Villanueva (1991)) claim that the negative relationship and the low growth rates are due to the fact that the high levels of external debt lead the private investment to a reduction.

In the literature there is great interest about the effects of debt on economic growth for developing countries. Using OLS estimation method for a sample of 81 developing countries, Cohen (1993) estimated an investment equation. He shows that the slowdown of investment in developing countries cannot be explained by the level of debt. Cunningham (1993), using a sample of sixteen heavily indebted nations, examined the relationship between economic growth and the level of (total) debt. The author found that that debt has a negative effect on the economic growth as the productivity of capital and labour are significantly reduced. Also Deshpande (1997) find negative relationship between external debt and economic growth for developing countries. The authors Rockerbie (1994) and Sawada (1994) in their works indicate that the decrease in economic growth and investment is due to the external debt.

Were (2001), tried to analyze the debt overhang problem (Kenya) and find evidence for its impact on economic growth. He used data from 1970 to 1995, but he didn't find any impact. In a recent work Pattillo, Poirson and Ricci (2002) find that the average impact of debt on per capita GDP growth is negative only for high levels of debt. Similarly Schclarek (2004) employing time series data over a period of 1970 to 2002 for 83 developing and industrial countries didn't find evidence about the relationship between debt and productivity. In this study he finds that for developing countries a higher growth rate is associated with a lower debt level.

Mohamed (2005), investigated the relationship debt indebtedness and economic growth for Sudan using annual data from 1978 to 2002. He found that inflation and debt avert growth. On the other hand he found exports to have a positive effect on economic growth. Adepoju et al. (2007) analyzed the economy of Nigeria using data from 1962 to 2006. They concluded that economic growth for Nigeria is hampered by the debt. Focusing on 6 Pacific Island countries for the period 1998-2004 Jayaraman et al. (2008), concluded that there is a significant positive relationship between debt and GDP, and inverse relationship between growth and higher fiscal deficit.

In a recent survey Hameed at al. (2008) tried to explore the effect of debt, capital stock and labour force on growth for a period of 1970-2003 for Pakistan. They found that economic growth is hampered by the adverse effect of debt on capital productivity and labour. Focusing on 27 Latin American and Caribbean countries for the period 1970-2003, Butts (2009) tried to investigate the relationship between economic growth and debt. He found that there is evidence of Granger causality in half of these countries (13).

3. Data

This study uses annual time series data on GDP per capital and Gross Debt (as percentage on GDP) sourced from IMF (International Monetary Fund). The data cover the period between 1980 and 2010 in Greece. The logarithm of GDP and External Debt are used in the empirical analysis. The transformation of the series to logarithms is intended to eliminate the problem of heteroskedasticity.

4. Econometric methodology

According to Ogunmuyiwa (2011) we use the model $GDP_t = f(DEBT_t)$ and $GDP_t = \beta_0 + \beta_1(DEBT_t) + \mu_t$

In order to avoid spurious regression outcomes on the time series data, we are using unit root tests that affirm the stationarity of the series. In this paper we use two kinds of unit roots tests. First of all we use the traditional unit roots tests which do not take into account structural breaks such as Augmented Dickey-Fuller (ADF) tests (Dickey and Fuller, 1979 and 1981) the Phillips-Perron test (1988) and the test of Kwiatkowski et al. (1992). The second kind of unit root tests we use are the tests that take into account one structural break such as Zivot and Andrews (1992) and Perron (1997). The third method we use in the paper is the Bai Perron(1998, 2001) method for estimating linear regression models subject to multiple breaks. Finally we have used Granger causality analysis in order to investigate the relationship between GDP and External Debt.

4.1. Unit root tests without structural break

4.1.1. ADF test

$$\Delta y_t = c + \alpha y_{t-1} + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{1}$$

$$\Delta y_t = c + \alpha y_{t-1} + \beta_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \tag{2}$$

The first equation (1) tests the null of a unit root against a mean stationarity in yt (y is the time series we examine each time). The second equation (2) tests the null of a unit root against the alternative of trend stationarity (ΔYt-j is lagged first differences)

4.1.2. Phillips Perron (PP test)

The PP test (1988) makes the semi –parametric correction for autocorrelation and it’s more powerful in the case where we have weakly autocorrelation and heteroskedastic regression residuals. We can say that Phillips Perron test is an extension of the ADF test.

4.1.3. KPSS test

Unlike most of the unit root tests Kwiatkowski-Phillips-Schmidt-Shin (1992) provide a test where the null hypothesis is that a series is stationary. The test has been developed to complement unit root tests as the last have low power with respect to near unit root and long run trend process.

4.2. Unit root tests with structural break

4.2.1. Zivot and Andrews model

Zivot and Andrews (1992) proceed with three models to test for a unit root: model A, which permits a one-time change in the level of the series; model B, which allows for a one-time change in the slope of the trend function, and model C, which combines one-time changes in the level and the slope of the trend function of the series. The 3 models are

$$\Delta Y_t = \kappa + \alpha * Y_{t-1} + \beta * t + \theta_1 DU_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t$$

(Model A)

$$\Delta Y_t = \kappa + \alpha * Y_{t-1} + \beta * t + \gamma_1 DT_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t$$

(Model B)

$$\Delta Y_t = \kappa + \alpha * Y_{t-1} + \beta * t + \vartheta_1 DU_t + \gamma_1 DT_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t$$

(Model C)

DUt is an indicator dummy variable for a mean shift occurring at each possible break-date (TB) while DTt is corresponding trend shift variable:

$$DU_t = \begin{cases} 1 & if\ t \succ TB \\ 0 & otherwise \end{cases} \quad \text{and} \quad DT_t = \begin{cases} t - TB & if\ t \succ TB \\ 0 & otherwise \end{cases}$$

The null hypothesis in all the models is that α=0, which means that the series {yt} contains a unit root with a drift that excludes any structural break. The alternative hypothesis is that α<0. It implies that the series is a trend-stationary process with a one-time break occurring at an unknown point in time.

4.2.2. Perron test

Perron (1997) proposed a unit root test which allows for an endogenous structural change. According to Perron (1997, p.358) we have 2 equations. In the first model the unit root test is performed using the t –statistic for testing a=1 in the following regression:

$$Y_t = \mu + \vartheta DU_t + \beta_t + \delta D(T_b)_t + \alpha Y_{t-1} + \sum_{i=1}^{k} c_i \Delta Y_{t-1} + e_{t*} \qquad (3)$$

where: $DU_t = 1 \quad (t \succ T_b)$ and $D(T_b)_t = 1 \quad (t = T_b + 1)$, T_b denotes the time at which the change in the trend function occurs; t is a linear time trend; Δ is the first-difference operator; et are white noise error terms. Moreover, as the second model (Model 2), the test is performed using the t-statistic for the null hypothesis that α=1 in the regression:

$$Y_t = \mu + \vartheta DU_t + \beta_t + \gamma DT_t + \delta D(T_b)_t + \alpha Y_{t-1} + \sum_{i=1}^{k} c_i \Delta Y_{t-1} + e_{t*} \qquad (4)$$

where: $DT_t = 1 \quad (t \succ T_b)_t$ is the dummy variable. We conduct regression (2) for $k + 3 \leq T_b \leq T - 3$. In the above equations (1) and (2), the break date, Tb, and lag length, k, are treated as unknown. The break date, Tb, is selected based on the minimum t-statistic for testing α = 1 (see Perron, 1997, pp. 358—359). For each Tb, the selection of lag length, k, is selected by t-sig criterion with maximum lag length, k max = 5 (see Perron, 1997, p. 359).

4.2.3. The Bai-Perron method

Bai and Perron (1998, 2001) proposed a method for estimating linear regression models subject to multiple breaks. The model assumes that the dependent variable, yt, is related to a set of state variables, xt−1 but that the relationship has been subject to q breaks up to time T :

$$y_t = \beta_1' x_{t-1} + \hat{u}_t \qquad t = 1,2,...,T_1$$

$$y_t = \beta_2' x_{t-1} + \hat{u}_t \qquad t = T_1 + 1,...,T_2$$

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$$y_t = \beta_{q+1}' x_{t-1} + \hat{u}_t \qquad t = T_q + 1,...,T$$

$T_1 \prec T_2 \prec ... \prec T_q \prec T$ and Ut is a is a disturbance term. The Bai and Perron method permits consistent estimation of the number and location of the breakpoints and the parameters.

The model it's possible to be restricted to allow partial breaks that only affect some of the regression coefficients. Because the breaks are viewed as deterministic and the approach thus does not require specifying the underlying process that generated the breaks in the first place. The approach relies on a number of design parameters such as the maximum number of breaks and the minimum distance between breaks.

We can determine the number of the breaks with many ways. One approach is to determine the number of breaks sequentially by testing for q + 1 against q breaks. Alternatively a global approach of testing for q breaks against no breaks can be used. Finally, the number of breaks can be selected by using penalized likelihood methods such as the Schwarz information criterion (SIC) or Akaike's information criterion (AIC) which differ in terms of the penalty they apply to the inclusion of additional breakpoint parameters. All of the above and other practical issues are further discussed in Bai and Perron (2001).

4.3. Granger causality test

The test procedure as described by (Granger, 1969) is illustrated below:

$$GDP = \sum_{j=1}^{K} A_j ED_{t-i} + \sum_{j=1}^{K} B_j GDP_{t-j+Uit} \tag{5}$$

$$DEBT = \sum_{j=1}^{K} C_i DEBT_{t-i} + \sum_{j=1}^{K} D_j GDP_{t-j+U2t} \ . \tag{6}$$

Equation (5) represents that current GDP is related to past values of itself as well as that of DEBT and vice- versa for Eq. (6).Unidirectional causality from DEBT to GDP is indicated if the estimated coefficient on the lagged DEBT in equation (5) are statistically different from zero as a group and the set of estimated coefficients on the lagged GDP in Eq. (6) is not statistically different from 0.The converse is the case for unidirectional causality from GDP to DEBT. Bilateral causality exists when the sets of DEBT and GDP coefficient are statistically different from 0 in both regressions (Gujarati, 2004). (Note: we are using the variables in first differences)

5. Empirical Results

5.1. Unit Root Tests without Structural Break

Before we will proceed to the analysis we have to determine the integration order of the variables. The results of the tests we have used are presented in table 1. All the variables are expressed in natural logarithms so that elasticities can also be determined.

Table 1. *Unit Root Tests without Structural Break*

	Dickey – Fuller			Phillips - Perron		KPSS	
	τ_μ	τ_τ		τ_μ	τ_τ	η_μ	η_τ
LGDP	0.163 [0.965]	-3.201 [0.059]	1	0.0050 [0.952]	-2.4835 [0.333]	0.690**	0.698***
LDEBT	-2.602 [0.022]	-2.475 [0.337]	1	-2.456 [0.027]	-2.407 [0.369]	0.652**	0.182**
ΔLGDP	-3.580** [0.013]	-3.383 * [0.073]	0	-3.916 *** [0.005]	-3.209 [0.102]	0.160	0.080
ΔLDEBT	-4.028*** [0.004]	-4.337 ** [0.009]	0	-4.118 *** [0.003]	-4.423 *** [0.008]	0.289	0.053

Notes: τ_μ is the t-statistic when a time trend is not included in the equation and τ_τ is the t-statistic when a time trend is included in the equation. The calculated statistics are those reported in Dickey-Fuller (1981). The critical values for the tests of Dicky – Fuller and Phillips – Perron are at 1% –3.67, at 5% –2.96 and at 10% –2.62 for τ_μ and –4.36, –3.60 and –3.23 for τ_τ respectively.

η_μ and η_τ are the KPSS statistics for testing the null hypothesis that the series are I(0) when the residuals are computed from a regression equation with only an intercept and intercept and time trend, respectively. The critical values at 1%, 5% and 10% are 0.739, 0.463 and 0.347 for η_μ and 0.216, 0.146 and 0.119 for η_τ respectively (Kwiatkowski et al, 1992, Table 1).

***, **, * indicate significance at the 1, 5 and 10 percentage levels.

The results according to the tests of ADF, Phillips-Perron and KPSS statistics, have showed that all the explanatory variables are integrated of order I (1).

5.2. Zivot Andrews results

Table 2. *Zivot Andrew's test*

	t-Statistic	Prob. *	Break Point
Zivot-Andrews test statistic (DLGDP)	-3.970220	0.009121	2003
Zivot-Andrews test statistic (DLDEBT)	-1.644756	0.001550	1994
1% critical value:	-5.34		
5% critical value:	-4.93		
10% critical value:	-4.58		

The results for Zivot and Andrew unit root test are presented in Table 2. The results suggest that we can reject the null of unit root for GDP and DEBT. At the same time, the test identifies endogenously the point of the most significant structural break in every time series examined in the paper. Table 2 tells us about the break dates for each variable. The Break point for the variable of DEBT is 1994 (since 1994 the ratio of debt to GDP has remained above 94% and after that year the ratio rapidly grew above 100%). The Break point for the variable of GDP was 2003 (after that year the real GDP growth ratio started to fall.

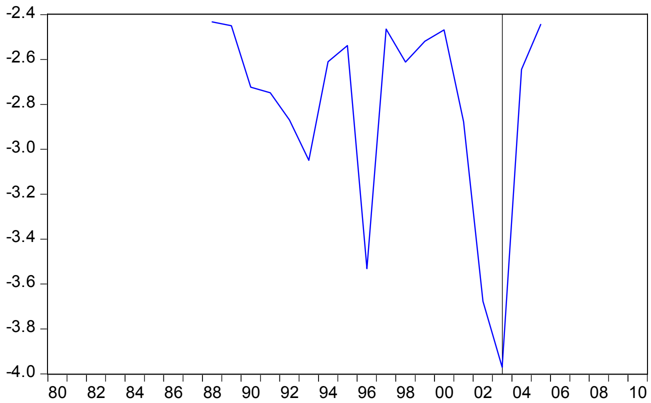

Figure 1. *Zivot – Andrew's Breakpoint for DLGDP (2003)*

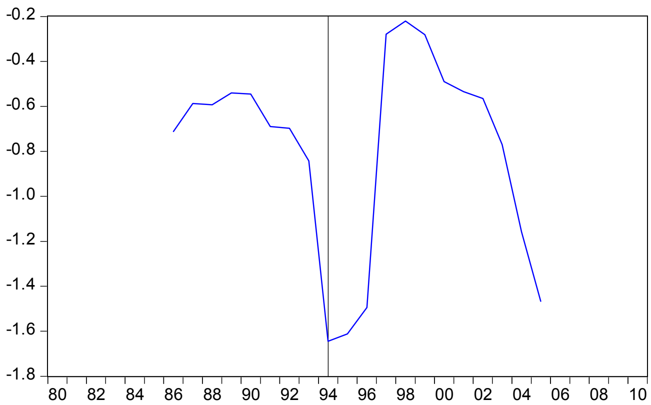

Figure 2. *Zivot – Andrew's Breakpoint for DLDEBT (1994)*

5.3. Results of Perron's unit root test

Table 3. *Perron's Unit Root Test*

	t-Statistic	Break Point
Perron Unit Root Test (DLGDP)	-5.699543	2002
Perron Unit Root Test (DLDEBT)	-5.981288	1993
1% critical value:	-5.92	
5% critical value:	-5.23	
10% critical value:	-4.92	

As we can see from the results which are presented in table 3 the break points for the variables of GDP and DEBT are 2002 and 1993 respectively. If we will compare the results of the two tests we see that they are slightly different (they differ by one year). The results of the Perron's test have shown a break point one year earlier that the Zivot Andrews test.

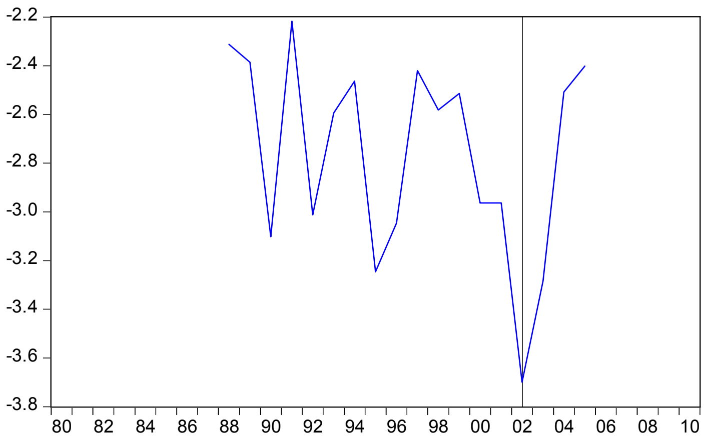

Figure 3. *Perron's Breakpoint DLGDP (2002)*

Figure 3. *Perron's Breakpoint DLDEBT (1993)*

5.4. Results of Bai-Perron's breakpoint test

The next test we have obtained was the Bai-Perron's breakpoint test. In table 4 we report the optimal number of breakpoints (i.e the one associated with the minimum BIC score or the maximum Log – Lik score). The optimum number of breakpoints we have in our model is 3 and the breaks were in year 1986, 1992 and 2001.

Table 4. *Bai-Perron's breakpoint Test*

Breakpoints	0	1	2	3	4	5	6
BIC	-47.87189	-51.46029	-47.57901	-53.72965	-48.69511	-48.73396	-32.17504
Log-Lik	30.73834	39.33493	44.19669	54.07441	58.35953	65.18135	63.70428
RSS	0.226298	0.127580	0.092262	0.047757	0.035889	0.022775	0.025132
N. Coefs	4.000000	8.000000	12.00000	16.00000	20.00000	24.00000	28.00000
Chosen number of breaks: 3							
Breaks :	1986						
	1992						
	2001						

5.5. Granger causality test

Table 5. *Granger causality test*

Null Hypothesis:	Obs	F-Statistic	Prob.
DLDEBT does not Granger Cause DLGDP	28	1.13476	0.3388
DLGDP does not Granger Cause DLDEBT		0.21841	0.8054

Having affirmed the stationarity of the series, we then proceed to find the causality using the Granger causality test as defined by Granger (1969). The results are shown in Table 5 and clearly we can conclude that they fail to support any strict causality between Debt (DEBT) and economic growth in Greece. Thus, it can be affirmed that the variables are exogenous of one another, but the degree of exogeneity between the variables cannot be determined easily. Hence, it can be stated that external debt is not a specific factor determining the rate of economic growth or economic slowdown in Greece. Our finding is in confinement with the findings of Afxentiou and Serletis (1996a) who stated that indebtedness is not a specific factor of per capital income growth. Also our findings are in confinement with Bullow and Rogof (1990) propositions that public debt of developing countries is a symptom rather than a cause of economic slowdown.

6. Conclusions

In this paper we are trying to determine if economic growth can be promoted by debt in Greece. Many researches have shown that causation between debt and growth could not be established in developing countries and public debt could thus not be used to forecast improvement or slowdown in economic growth in Greece.

In order to examine that relationship we have used some stationarity tests. First of all we have used the traditional unit roots tests which do not take into account structural breaks such as Augmented Dickey-Fuller (ADF) tests (Dickey and Fuller, 1979 and 1981) the Phillips-Perron test (1988) and the test of Kwiatkowski et al. (1992). The results have shown that all of our variables are stationary of order one. The second kind of stationarity tests we have used are the tests that take into account one structural break such as Zivot and Andrews (1992) and Perron (1997). Here we have found that with Zivot and Andrews's method the Break point for the variable of DEBT was 1994 and for the variable of GDP was 2003. The results of Perron's test were slightly different and give us different break points for the variables (GDP and DEBT are 2002 and 1993 respectively). We have used also the Bai Perron's (1998, 2001) method for estimating linear regression models subject to multiple breaks. The test has shown that the optimum number of breakpoints we have is 3 and the breaks were in year 1986, 1992 and 2001. Finally we have used Granger causality analysis in order to investigate the relationship between GDP and Public Debt. The results suggested that we cannot establish causality between debt and growth in Greece.

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