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Public Debt Thresholds: An Analysis for Cyprus

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Abstract

We examine whether a threshold exists in the debt-to-GDP and output growth relationship. The results suggest that a threshold exists, and that prior to the threshold level, i.e. when debt is lower, government spending has a negative impact on the economy, while after it the impact turns positive. When the unemployment rate is used as the threshold variable, we find that government spending has no impact until unemployment reaches 10%, after which a strong positive impact on GDP growth is registered. Overall, the results suggest that while additional government spending can crowd out the private sector when the economy is booming, it can still have a strong positive impact on GDP when unemployment is high. As such, the results highlight the fact that what matters is the timing and not the debt-to-GDP level per se.

Keywords: public debt, threshold, unemployment, debt-to-GDP

1. Introduction

Public debt became an anathema in the European Union since the Papandreou announcement in 2009, in which the Greek government admitted that the country had published erroneous public debt figures, and the revised numbers showed that Greece held one of the largest debt piles in the world. More so, the country could not service it as it stood, and was forced to adjust its public finances using intense austerity measures, including a debt haircut, known as the PSI (Private Sector Involvement).[1]

The perils of Greece's public debt were not limited to the country. Soon enough (in 2011), Portugal was also forced to require a bailout, while the country's only way to get out of the crisis was also marked by intense austerity policies. Like Greece, Portugal's austerity policy had significant effects on the well-being of its citizens, as even hospitals decreased elective stay days, most likely due to reduced capacity (Perelman et al., 2015).

The European debt crisis progressed, other countries, such as Ireland, Italy, Spain, and Cyprus, followed suit, as their public debt stock increased to unsustainable levels. In

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[1] For more details, see Xafa (2013).

every country, austerity measures were implemented, notably when the economies were already in a slump, exacerbating the already tight economic environment. Given that it took the countries at least three years to successfully exit their assistance programmes, the toll austerity measures had on the citizens of each country was significant (Antonakakis and Collins, 2014).

Thus, after the whole of Europe has witnessed first-hand the perils of public over-indebtedness, the question which remains unanswered is simple yet highly important: how much debt is too much debt?

The answer which attracted the most attention was that of Reinhart and Rogoff (2010), who imposed arbitrary debt levels at 30%, 60%, and 90% of GDP, and found that debt ratios above 90% of GDP were related to negative growth rates. This was also injected into the policy sphere, with European Central Bank presentations also suggesting that the empirical literature supports a 90% threshold rule (Checherita-Westphal and Jacquinot, 2019).

However, as Herndon et al., (2013) showed, Reinhart and Rogoff (2010) conclusions were the result of "*selective exclusion of available data, coding errors and inappropriate weighting of summary statistics lead to serious miscalculations that inaccurately represent the relationship between public debt and GDP growth among 20 advanced economies*" (page 2). In general, the authors' conclusions refute the Reinhart and Rogoff's claim that the relationship between public debt ratios and GDP growth is negative.

On a similar note, Panizza and Presbitero (2013) comment that there is no paper that can make a strong case for a causal relationship going from debt to economic growth. Furthermore, the authors also suggest that the presence of thresholds and, more in general, of a non-monotone relationship between debt and growth is not robust to small changes in data coverage and empirical techniques. Still, as Eberhardt and Presbitero (2015) note, using a static, non-linear model, they find some support for a negative relationship between public debt and growth, but no evidence for a similar, or common for that matter, debt threshold across countries.

In a further study examining for a non-linear effect, Égert (2015a, b) finds that a tipping of about 20% GDP can be found, even though other possibilities, such as a 50% debt threshold is also found. For some countries including the United States, a nonlinear negative link can be detected at about 30% of GDP, while for others, no nonlinearities can be established. Finally, other papers find that strong threshold effects are only found on democracy, implying that higher debt results in lower growth for countries in the low-democracy regime (Kourtellos et al., 2013).

In the euro area, Gómez-Puig and Sosvilla-Rivero (2017) use a sample of 11 countries (not including Cyprus) to find that there appears to be little relationship between debt and growth after the Stability Growth Pact ceiling of 40% to 50%. Still, the specification used in the study is not suitable for threshold analysis, given that the threshold level is arbitrarily selected.

Overall, the above short review has provided insights as to how much importance is placed on the debt-growth relationship, especially for policymakers. Despite the importance of identifying whether a debt-growth threshold exists, and whether the relationship changes, there has been no study which has examined this for Cyprus.

To this end, we propose the use of a Smooth Transition Regression (STAR) model, proposed by Teräsvirta (1994), allowing us to test for potential non-linearities in the relationship between public debt and growth. The remainder of this paper is

organized as follows: the next section offers an overview of the methodology and the data, while section 3 offers the results and the subsequent conclusions these lead to. Finally, section 4 offers the key takeaways from this paper and provides the relevant policy implications.

2. Methodology and Data

The usual linear regression model assumes that the parameters of the model do not vary across observations, despite acknowledging the possibility of structural change in the variable. In practice though, the possibility of a change in parameter estimates across different time periods in the sample can plays an empirically relevant role in applied time series analysis. To this end, a large part of the empirical literature has been devoted at developing testing and estimation methodologies for regression models that allow for change (see Hansen (2001) and Perron (2006) for an overview).

One of the first tests for parameter instability and structural change in regression models dates back to Chow (1960), who tested for regime change at a priori known dates using an F-statistic. As the need to specify already known dates for the breaks can be restrictive, Quandt (1960) modified the Chow framework to consider the F-statistic with the largest value over all possible break dates, while Andrews (1993) and Andrews and Ploberger (1994) derived the limiting distribution of the Quandt test statistics.

More recently, Bai (1997) and Bai and Perron (1998, 2003a) provide theoretical and computational results that further extend the existing Quandt-Andrews framework to allow for multiple unknown breakpoints. As per the derivations, the regime breakpoints may be known and specified a priori, or they may be estimated using the Bai (1997), Bai and Perron (1998), and related techniques.

In that category of models, Smooth Transition Autoregressive (STAR) modelling (Teräsvirta, 1994) is an extremely popular approach for nonlinear time series analysis. STAR models, which are a special case of Smooth Transition Regression (STR) models, embed regime-dependent linear auto-regression specifications in a smooth transition nonlinear regression framework.

Similar in concept to discrete Threshold Regression (TR) models, STR models differ in that regime switching occurs smoothly when an observed variable crosses the unobserved thresholds. Because of this smooth response, STR models are often thought to have more "realistic" dynamics than their discrete TR counterparts. STR models have been widely used (e.g. Teräsvirta and Anderson, 1992; Teräsvirta 1994).

More formally, considering the linear regression model with *T* periods and *m* potential breaks (and thus *m+1* regimes), the relevant regression model becomes:

$$y_t = Z_t'\delta_j + W_t'\beta + \epsilon_t \quad (1)$$

where $j = 0,1,2 \ldots m$ refers to the number of regimes. Importantly, the regressors are divided to two groups, where W refers to the variables that do not change across regimes and Z to the variables that have regime-specific coefficients. Suppose that there is an observable threshold variable q_t, and strictly increasing threshold values, such that $(\gamma_1 < \gamma_2 < \ldots < \gamma_n)$, then we are in a regime j if: $\gamma_j \leq q_t < \gamma_{j+1}$. For initialization purposes, $\gamma_0 = -\infty$ and $\gamma_{n+1} = +\infty$.

In other words, we are in regime *j*, if the value of the threshold variable is at least as large as the *j*-th threshold value, but on as large as the *(j+1)*-th threshold value. In the single threshold model, i.e. one with two regimes, we have that:

$$y_t = Z_t'\delta_1 + W_t'\beta + \epsilon_t, \qquad if\ -\infty < q_t < \gamma_1 \tag{2}$$

$$y_t = Z_t'\delta_2 + W_t'\beta + \epsilon_t, \qquad if\ \gamma_1 < q_t < \infty \tag{3}$$

To generalize the above, an indicator function is used, $1(\cdot)$ which takes a value of 1 if the expression is true and is zero otherwise. Furthermore, defining $1_j(q_t, \gamma) = 1(\gamma_j \leq q_t < \gamma_{j+1}$, the *n+1* individual regime specifications can be combined in a single equation, such that:

$$y_t = W_t'\beta + \sum_{j=0}^{n} 1_j(q_t, \gamma) \cdot Z_t'\delta_j + \epsilon_t \tag{4}$$

As with any threshold model, the identity of the threshold variable and the regressors will determine the type of threshold specification. If the threshold variable is a lagged value of the dependent, then equation (4) will be a self-exciting model with delay *d*. Otherwise, it is a conventional threshold model. Similarly, if the regressors contain only a constant and lags of the dependent variable, we have an autoregressive (AR) model.

To reach the STAR model, however, we need to use a slight modification of equation (4). More particularly, we denote:

$$y_t = W_t'\beta + \sum_{j=0}^{n-1} 1_j(s_t; c, \gamma) \cdot Z_t'\delta_j + \epsilon_t \tag{5}$$

where $1_j(\cdot)$ is, as before, an indicator for the regime that depends on the observed variable s_t, where *c* represents one or more thresholds and γ is the threshold slope parameter. As before, W refers to the variables that do not change across regimes and Z to the variables that have regime-specific coefficients. If, as before, we seek to restrict ourselves to two regimes, then we would have that:

$$y_t = \{1 - 1_1(s_t; c, \gamma)\} \cdot Z_t'\delta_0 + 1_1(s_t; c, \gamma) \cdot Z_t'\delta_1 + W_t'\beta + \epsilon_t \tag{6}$$

where $1_0(s_t; c, \gamma) = \{1 - 1_1(s_t; c, \gamma)\}$, if we seek to construct a two-regime STR model, we replace the indicator function with a continuous transition function G, that returns values between 0 and 1. Thus, equation (6) would turn to:

$$y_t = 1_0(s_t; c, \gamma) \cdot Z_t'\delta_0 + 1_1(s_t; c, \gamma) \cdot Z_t'\delta_1 + W_t'\beta + \epsilon_t \tag{7}$$

where the properties of G depend on its functional form. The most popular and widely used functional form is the logistic form, specified as $G(s; c, \gamma) = \frac{1}{1+\exp(-\gamma(s-c))}$. Concerning its properties, the logistic function is monotonically increasing in *s* so that the two regimes correspond to the high and low values of the threshold variable

respectively. The threshold value c determines the point at which the regimes are equally weighted, while γ controls the speed and smoothness of the transition. As the sharpness of the movement increases, i.e. as $\gamma \to \infty$, the transition function approaches the indicator function and the model approaches the discrete threshold model. The interested reader can refer to more detailed discussions in Teräsvirta (1994), Eitrheim and Teräsvirta, and van Dijk et al., (2002).

Regarding the variables to be used, we propose the use of GDP growth as the dependent variable, given that we seek to find the extent at which government debt can have an impact on economic growth. Furthermore, we employ the unemployment rate as the dependent variable, given the known, Okun's law relationship between the two (Michail, 2019), with the aim of capturing the business cycle dynamics which are unrelated to the change in public debt.

Given our research question, on whether debt spending has an impact on growth, we also include the change in the final consumption expenditure of the general government (as a % of GDP) as an independent variable, which, if the threshold conjecture is correct, should have a different sign once the threshold is surpassed.[2]

Finally, with regards to the threshold variable, we will include the Cyprus debt-to-GDP ratio, in an effort to examine if and where a threshold may lie.[3] All variables were obtained from Eurostat, and the sample, limited by data availability, ranges from 2000q1 to 2019q2.

Further to the straightforward question with regards to whether a threshold exists after which higher debt can hurt the economy, i.e. make government spending ineffective, we also choose to use a different specification. In particular, we examine whether government spending is also affected by the state of the economy, by using the unemployment rate as the threshold variable. In other words, we examine whether government spending can have a higher or lower impact when unemployment is higher, thus providing a rationale to Keynes's (1964) suggestion that deficit spending is better in times of recession. More details can be found in the section that follows.

3. Estimation Results

Table 1 presents the results from the estimation where the Debt-to-GDP ratio serves as the threshold variable. As the results indicate, the threshold level stands at 73%, and it is significant at the 1% level. Interestingly, the results are not what one would expect: prior to that debt level, i.e. when debt is lower, government spending has a negative impact on the economy, while after it the impact turns positive. As figure 1 shows, this can be justified via the fact that when the Cypriot economy was enjoying high output growth rates, during the years of the Cyprus property and lending boom (Cleanthous et al., 2019; Michail and Thucydides, 2019), the impact from any additional spending would in fact crowd out private spending. On the other hand, as private spending eased, in the post-2011 years, government spending became much more important for the Cypriot economy. The results are furthermore supportive of other studies in the literature, such as Koursaros et al., (2020) with regards to private debt levels.

[2] Loans data were also used in some specifications; however, due to the short time span and the limited number of observations, these were insignificant.

[3] We use a rolling 4-quarter GDP estimate in order to obtain the ratio.

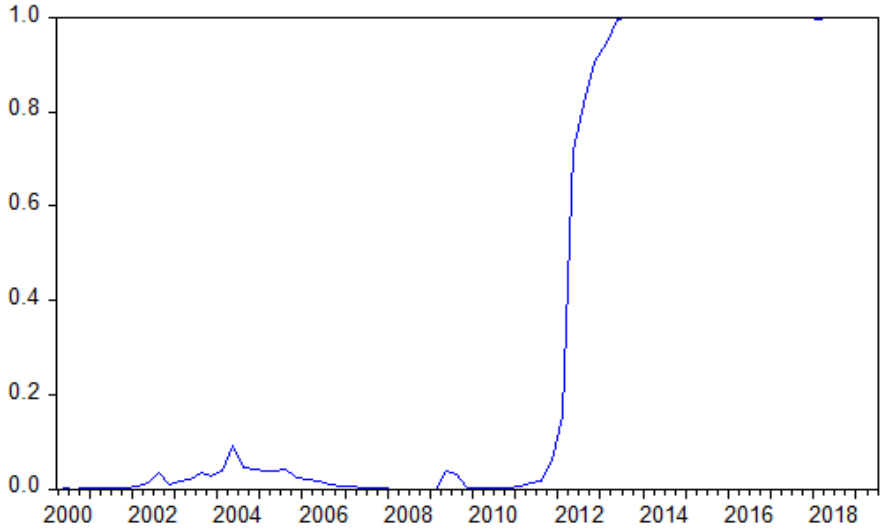
TABLE 1

Debt-to-GDP results

Dependent Variable: GDP Growth **Threshold Variable:** Debt-to-GDP	**Regime 1**	**Regime 2**
Government Spending (% of GDP)	-0.09** (0.05)	0.39*** (0.08)
Unemployment Rate	-2.51*** (0.66)	-1.61* (0.94)
Constant	4.06*** (0.43)	-4.23*** (0.65)
Threshold Level:	73.8***	
Slope:	0.34 (0.25)	
R-squared	0.76	
Observations	77	

FIGURE 1

Threshold Weights (debt-to-GDP)



The results, despite not confirming the expected "more debt is bad" dictum, in fact suggest that the impact from additional spending is highly dependent on the state of the economy, as Auerbach and Gorodnichenko (2012) note. If the economy is enjoying high rates of growth and unemployment is low, then there is no need for additional spending; on the other hand, the more the government spending, the better it would be for the Cyprus economy. Interestingly, the relationship between growth and unemployment is also stronger in regime 1, highlighting that the link between unemployment and GDP growth is stronger when times are good than when times are bad. This view is also in accordance with Michail (2019), suggesting that the Okun's relationship is regime-dependent.

TABLE 2

Unemployment results

Dependent Variable: GDP Growth	**Regime 1**	**Regime 2**
Threshold Variable: Debt-to-GDP		
Government Spending (% of GDP)	-0.06 (0.05)	0.88*** (0.19)
Constant	3.62*** (0.43)	-1.39 (0.97)
Threshold Level:	10.38***	
Slope:	14.76 (23.41)	
R-squared	0.37	
Observations	78	

FIGURE 2

Threshold Weights (unemployment)

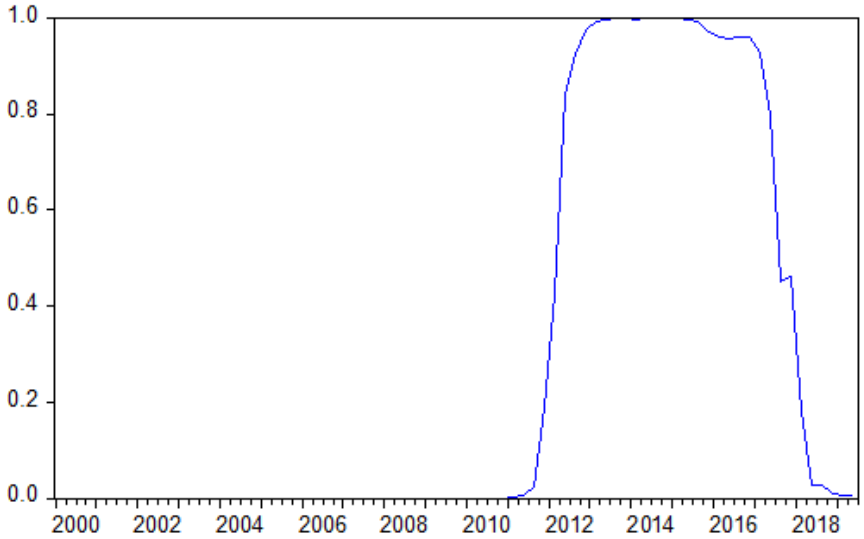


Table 2 presents the estimation results from the second specification, where the unemployment rate is used as the threshold variable. In this case, we see that when the unemployment rate is higher than 10.38%, government spending has a strong positive impact on GDP growth. On the other hand, we see that in regime 1, when growth is strong (constant value is at 3.62%), then government spending does not have any impact on growth. Figure 2 also confirms this, showing that when the unemployment rate was higher during the crisis years, regime 2 prevailed, while the effect decreased after 2017, at which point the weight was below 0.5.

It should be noted that the exact timing when government spending should take place appears to differ between the two specifications. According to figure 1, government spending remains in the positive regime with regards to its debt-to-GDP threshold, however, we see that there is no need for additional spending, as unemployment has already declined to less than 10.38%. As such, it would perhaps be best if a variety of methodologies were employed to estimate such points in time.

Overall, the two specifications underline the fact that government spending is best suited to increase when the economy is not performing well and unemployment is high. As table 1 shows, if more spending is injected in the economy when there is no need, then we can observe a "crowding out" effect, i.e. hampering growth instead of assisting it. However, this should not mean that cutting spending is always good: in times of a recession, i.e. when unemployment is higher, as figure 2 shows, austerity measures could further hurt the economy, by pulling out additional funds.

The results are broadly in line with the literature on the topic, such as Furceri, and Sousa (2011), who show panel evidence of such crowding out effects. Our findings supplement them in that we suggest that this crowding out is more likely to take place when the economy is experiencing high output growth rates, thus inviting future research to further delve in the topic. Furthermore, the lack of a long series of available data for important variables such as bank lending is also limiting the scope of our study. In the future, once more data becomes available, it would perhaps be easier to quantify this relationship. Furthermore, as data availability allows us to use a series containing more than just one economic cycle, the results would be significantly strengthened, and the conclusions reached would be far more robust.

4. Conclusions

This paper has elaborated on whether a threshold exists in the debt-to-GDP and output growth relationship. We find that a threshold does exist, however, not to the extent the majority of the literature expects. We find that prior to the threshold level, i.e. when debt is lower, government spending has a negative impact on the economy, while after it the impact turns positive. This can be justified via the fact that the Cypriot economy was enjoying high output growth rates prior to the crisis and during the years of the Cyprus property and lending boom. Consequently, the impact from additional spending would crowd out private spending.

When the unemployment rate is used as the threshold variable, we find that government spending appears to have no impact until unemployment reaches 10.38%, after which a strong positive impact on GDP growth is registered. Overall, the qualitative conclusions are similar to the ones in the previous paragraph: while additional government spending can crowd out the private sector when the economy is booming it can still have a strong positive impact on GDP when unemployment is high. As such, the results highlight the fact that what matters is the timing and not the debt-to-GDP level per se.

The policy implications of these findings are straightforward: government spending is best suited to increase when the economy is not performing well and unemployment is high. In the opposite case, if government spending rises when there is no macroeconomic justification for it, then we can observe a crowding out effect which would act more like a hurdle to sustainable growth instead of assisting it. This is particularly important given that there are limits with regards to how much spending a government can make, as the cost of debt will tend to increase when debt grows uncontrollably. Naturally, the conclusions are conditional on a number of factors, and namely the composition of government expenses. If government investment increases for productive purposes, e.g. infrastructure, then even though the impact on GDP would depend on the state of the economy at the time, the long-run effects would still be positive.

The findings are also supportive of the Keynesian view of how fiscal policy should be conducted, i.e. surpluses when the economy is growing and deficits when the economy is in a recession. In the Cypriot case, it appears that the "recession" measure is best viewed as the unemployment rate, which, if it increases above the aforementioned level, it should be viewed as a signal for expansionary fiscal policy. Finally, it should be mentioned that the use of bank lending data, once a longer time series becomes available, could also assist in determining how the government spending impact on growth changes when the financial sector effect on GDP is taken into consideration. Naturally, given the absence of such data, this is left for future research.

References

Andrews, D.W.K., (1993), "Tests for Parameter Instability and Structural Change With Unknown Change Point", *Econometrica*, 61(4): 821–856.

Andrews, D.W.K., and Ploberger. W., (1994), "Optimal Tests When a Nuisance Parameter is Present Only Under the Alternative", *Econometrica*, 62(6): 1383–1414.

Antonakakis, N., and Collins, A. (2014), "The impact of fiscal austerity on suicide: on the empirics of a modern Greek tragedy" *Social science & medicine*, 112: 39-50.

Auerbach, A. J., and Gorodnichenko, Y. (2012). Fiscal multipliers in recession and expansion. In *Fiscal policy after the financial crisis* (pp. 63-98). University of Chicago Press.

Bai, Jushan, (1997). "Estimating Multiple Breaks One at a Time," *Econometric Theory*, 13(3): 315–352.

Bai, J. and Perron, P., (1998), "Estimating and Testing Linear Models with Multiple Structural Changes," *Econometrica,* 66: 47–78.

Bai, J. and Perron, P. (2003a), "Computation and Analysis of Multiple Structural Change Models." *Journal of Applied Econometrics,* 18(1): 1–22.

Bai, J. and Perron, P. (2003b), "Critical Values for Multiple Structural Change Tests," *Econometrics Journal*, 18, 1–22.

Berben, R.P. and Jansen, W.J., (2005), "Comovement in international equity markets: A sectoral view", *Journal of International Money and Finance*, 24(5): 832–857.

Checherita-Westphal, C. and Jacquinot, P., (2018), "Economic consequences of high public debt and lessons learned from past episodes", ECFIN Workshop, Brussels, 18 January 2018.

Chow, G.C. (1960), "Tests of equality between sets of coefficients in two linear regressions." *Econometrica*, 28(3): 591-605.

Cleanthous, L. T., Eracleous, E. C., and Michail, N. A., (2019), "Credit, house prices and the macroeconomy in Cyprus", *South-Eastern Europe Journal of Economics*, *17*(1).

Eberhardt, M. and Presbitero, A.F., (2015), "Public debt and growth: Heterogeneity and non-linearity". *Journal of International Economics*, 97(1), pp.45-58.

Égert, B., (2015a), "Public debt, economic growth and nonlinear effects: Myth or reality?", *Journal of Macroeconomics*, 43(C): 226-238.

Égert, B. (2015b), "The 90% public debt threshold: the rise and fall of a stylized fact", *Applied Economics*, 47(34-35): 3756-3770.

Eitrheim, Ø. and Teräsvirta, T. (1996), "Testing the Adequacy of Smooth Transition Autoregressive Models," *Journal of Econometrics*, 74: 59–75.

Furceri, D., and Sousa, R. M., (2011), "The impact of government spending on the private sector: Crowding-out versus crowding-in effects", *Kyklos*, *64*(4): 516-533.

Gómez-Puig, M. and Sosvilla-Rivero, S., (2017), "Heterogeneity in the debt-growth nexus: Evidence from EMU countries" *International Review of Economics & Finance*, 51(C): 470-486.

Hansen, B.E. (2001). "The New Econometrics of Structural Change: Dating Breaks in U.S. Labor Productivity," *Journal of Economic Perspectives*, 15(4): 117–128.

Herndon, T., Ash, M., and Pollin, R., (2014), "Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff" *Cambridge Journal of Economics*, 38(2), 257-279.

Keynes, J. M., (1964). The general theory of employment, interest and money (1936). *The Collected Writings of John Maynard Keynes*, *7*, 1971-9.

Koursaros, D., Michail, N., and Savva, C., (2020), "Tell me where to stop: thresholds in the bank lending and output growth relationship". *Empirical Economics*, forthcoming.

Kourtellos, A., Stengos, T., and Tan, C. M., (2013), "The effect of public debt on growth in multiple regimes", *Journal of Macroeconomics*, 38: 35-43.

Michail, N. A., (2019), "Examining the stability of Okun's coefficient", *Bulletin of Economic Research*, *71*(3): 240-256.

Michail, N. A., and Thucydides, G., (2019), "The impact of foreign demand on Cyprus house prices", *Cyprus Economic Policy Review*, *13*(2): 48-71.

Panizza, U. and Presbitero, A.F., (2013), "Public debt and economic growth in advanced economies: A survey", *Swiss Journal of Economics and Statistics*, 149(2): 175-204.

Perelman, J., Felix, S., and Santana, R. (2015), "The Great Recession in Portugal: Impact on hospital care use" *Health Policy*, 119 (3): 307–315.

Perron, P. (2006), "Dealing with Structural Breaks," in Palgrave Handbook of Econometrics, Vol. 1: Econometric Theory, T. C. Mills and K. Patterson (eds.). New York: Palgrave Macmillan.

Quandt, R.E. (1960), "Tests of the hypothesis that a linear regression system obeys two separate regimes." *Journal of the American Statistical Association*, 55(290): 324-330.

Reinhart, C.M. and K.S. Rogoff (2010), "Growth in a time of debt", *American Economic Review*, 100(2): 573-78.

Terasvirta, T., and Anderson, H. M. (1992), "Characterizing nonlinearities in business cycles using smooth transition autoregressive models", *Journal of Applied Econometrics*, 7(S1): S119-S136.

Teräsvirta, T. (1994), "Specification, Estimation, and Evaluation of Smooth Transition Autoregressive Models," *Journal of the American Statistical Association*, 89 (425): 208–218.

van Dijk, D., Teräsvirta, T., and Franses, P.H. (2002), "Smooth Transition Autoregressive Models—A Survey of Recent Developments," *Econometric Reviews*, 21(1): 1–47.

Xafa, M. (2013), "Life after Debt: The Greek PSI and its aftermath", *World Economics*, 14 (1): 81–102.