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Structural Breaks and Nonlinearity in US and UK Public Debt

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ABSTRACT

This paper investigates the short-term dynamics for public debts in the US and the UK over more than four decades. We check for structural changes in the data and assess nonlinearity and switching-regime hypotheses using several linearity tests. Our findings point to multiple structural breaks due to economic downturns, oil shocks, and financial and political instability. We also identify different regimes for which the adjustment is asymmetric and nonlinear, in particular, since 2003 and around the Great Recession.

Keywords: Public debt, structural breaks, nonlinearity.
JEL classification: C22, H6.

1. Introduction

The government deficit limits imposed by the Maastricht Treaty, the Stability and Growth Pact and the new Fiscal Compact in the Economic and Monetary Union (EMU), the creation of fiscal policy committees, or the Balanced Budget Amendment in the U.S. are just a few examples of initiatives designed to impose discipline in the conduct of fiscal policy and to contribute for long-term sustainability of public debt.

However, the severity of the most recent financial turmoil and the need to promote the economic recovery and to rescue the banking system forced many governments to adopt expansionary fiscal policies, which led public debt to reach historical levels. In the US, public debt has substantially increased between 1980 and 1990. It fell under the Clinton administration, before massively rising again in 2001-2012 due to tax reductions, the economic recession and the increase in military spending. For the UK, public debt (in percentage of GDP) increased from 33% to 45% between 1991 and 2000. Public debt currently represents 100% of GDP in the US and close to 93% in the UK.

The shift from stimulus to austerity came in 2010 and was the natural consequence of the pressure towards achieving a sustainable path for public debt. However, while European countries are guided by the role of fiscal consolidation as pre-requisite for long-term growth, other countries, such as the US and the UK, have recognized that fiscal austerity can be detrimental for growth in the short-term and are trying to fine-tune the optimal trade-off with fiscal consolidation.

In the literature, the study of public debt has always been a crucial question, but the recent and sharp deterioration of the fiscal stance associated to the financial crisis has renewed the interest of academics, central banks and policymakers on the topic (Agnello and Sousa, 2011; Afonso and Sousa, 2012; Agnello et al., 2012; Sousa, 2012).

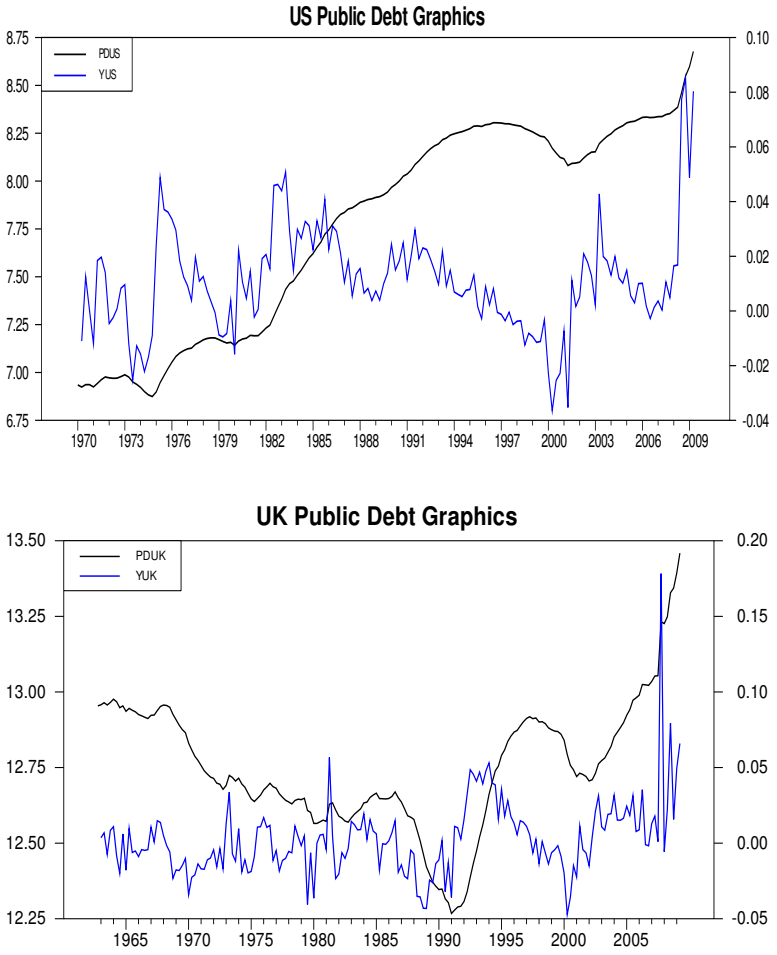
In this paper, we investigate the dynamics of public debt for two major developed countries - the US and the UK -, while testing for structural changes and nonlinearity in public debt dynamics. We find multiple structural breaks that can be explained by economic recessions, oil shocks, and financial and political instability. We also identify different regimes for which the adjustment is asymmetric and nonlinear, namely, after 2003 and in the period of the Great Recession.

2. Data and Preliminary Results

We use quarterly data for public debt, covering the period 1970:1-2009:2 in the case of the US, and 1962:4-2009:2 in the UK.

Figure 1 plots the evolution of (the log of) the level and the first-difference of public debt. It can be seen that the level of public debt (black line) has significantly increased since 1982 in the US and since 1990 in the UK. Additionally, the growth rate of public debt (blue line) reveals: (i) high volatility; (ii) several structural breaks; and (iii) a strong increase by the end of the sample period (8% for the US and 18% in the UK).

Figure 1: Public debt in the US and the UK



Note: PDUS and PDUK refer to the logarithm of public debts for the US and the UK, respectively, while YUS and YUK denote their first-differences.

In order to assess the statistical properties of the public debt series, in Table 1, we start by applying the Augmented Dickey-Fuller (ADF) tests, which show that they are nonstationary in levels, but are stationary in first-differences. Then, we use the unit root tests of Phillips-Perron (PP), which are more robust to autocorrelation and heteroscedasticity, and corroborate the previous findings. We also implement the KPSS test, which assesses the null hypothesis of stationarity against the alternative of a unit root.

At the 5% significance level, only the US public debt is integrated of order one (I(1)). Given such divergence, we apply the unit root test of Zivot and Andrews (1992), denoted by Z&A, which has the advantage of estimating the break point rather than considering it as exogenously fixed. It shows that both US and UK public debt series are I(1). As a result, we now focus on the first-differences of public debt.

Table 1: Unit root tests

	ADF		PP		KPSS		Z&A	
	Level	Δ	Level	Δ	Level	Δ	Level	Δ
US	1.87 [a]	-1.96[a]	3.31[a]	-2.92[a]	1.44[b]	0.11 [b]	-3.62	-4.81
UK	0.71 [a]	-7.88 [a]	0.70[a]	-8.41[a]	0.37[b]	0.53 [b]	-1.87	-4.96

Note: "Level" and "Δ" designate series in levels and in first-differences, respectively. (a): model with neither trend nor constant; (b): model with constant, but without trend; and (c): model with trend and constant. The critical values for the ADF and the PP tests at 5% statistical level are -1.95 for model (a), -2.89 for model (b) and -3.45 for model (c). The critical values for the KPSS tests at 5% significance level are 0.463 and 0.146 for model (b) and model (c), respectively. Finally, the critical value for the test of Zivot and Andrews (1992), denoted by Z&A, is -4.42, at 5% significance level.

The descriptive statistics for the US and the UK growth rate of public debt are summarized in Table 2. First, changes in public debt are somewhat volatile. Second, the normality and the symmetry hypotheses are rejected for both countries and a significant leptokurtic characteristic is more pronounced in the UK, suggesting departure from normality and, possibly, linearity. Third, public debt reached record levels after the housing market downturn (2008:4 for the US and 2007:4 for the UK). The ARCH effect and the null mean hypotheses are not rejected for the UK, indicating proportional changes in the public debt.

Table 2: Descriptive statistics

	Mean	St. Dev.	Min	Max	Skewness	Kurtosis	JB (p-value)	t-stat (p-value)	ARCH (p-value)
YUS	0.011	0.01	-0.04 (2000:2)	0.08 (2008:4)	0.80	5.54	0.00	0.00	0.00
YUK	0.002	0.02	-0.04 (2000:2)	0.17 (2007:4)	2.20	15.9	0.00	0.14	0.34

Note: JB refers to the Jarque-Bera test.

3. Econometric Modelling

3.1 Structural Break Tests

To investigate the existence of structural breaks in the growth rate of public debt, we use the Bai and Perron (2003) methodology. Formally, we denote by z_t the growth rate of public debts and retain the following mean-shift model with m breaks, $(T_1, T_2, ..., T_m)$

$$z_t = \mu_j + \varepsilon_t,\ t = T_{j-1} + 1,...,T_j, \qquad (1)$$

where $j = 1,...,m+1$, $T_0 = 0$ and $T_{m+1} = T$, μ_j refers to the regression coefficients with $\mu_i \neq \mu_{i+1}$ $(1 \leq i \leq m)$, and ε_t corresponds to the error-term. According to Bai and Perron (1998), μ_j is estimated by OLS method and the break dates $(T_1, T_2,...,T_m)$ are determined under the condition that $T_i - T_{i-1} \geq [\gamma T]$, where γ is an arbitrary, small and positive number and [γT] is the integer part of the argument.

In accordance with Bai and Perron (2003), the structural break test is carried out in several steps. First, we test the null hypothesis of "no break" against its alternative of an unknown number of changes, using the $UDmax\,F_T$ or the $WDmax\,F_T$ tests. If the hypothesis of "at least one structural break exists" is not rejected, we determine, in the second stage, the number of breaks using the $\sup F_T(l+1/l)$ test. This test checks the null hypothesis of l breaks against the alternative of an additional break. We apply this test and report the main findings in Table 3.

On the one hand, we check the null hypothesis of "no break" against its alternative of "*a single structural break at an unkonw point within the sample"* using the Andrews-Quandt (A&Q) and the Andrews-Ploberger (A&P) structural break tests for a linear regression. Both tests reject the null hypothesis and suggest evidence of structural breaks in the US and the UK public debt in 2003 and 1991, respectively. Interestingly, such dates are associated with the rise in government spending due to the first and second Gulf wars.

On the other hand, the Bai and Perron (2003) test, denoted by B&P, reveals eight structural breaks in the US and five in the case of the UK. Such changes reflect several economic downturns and events such as the 1973 oil shock, the 1982 debt crisis, geopolitical events, the 2001 burst of the technological bubble or the 2007-2008 subprime and global financial crisis. The regression coefficients indeed show higher values for the last structural break period, thereby, indicating that the impact of the recent financial turmoil on public debt was the strongest in the sample period.

Table 3: Structural break tests

US

Single structural break tests		**B&P test**							
A&Q test	A&P test	Break dates							
(p-value) 0.05	(p-value) 0.09	$\hat{T}_1$ 1973:1 (1972:4-1973:4)	$\hat{T}_2$ 1974:4 (1974:3-1975:1)	$\hat{T}_3$ 1976:2 (1975:3-1976:3)	$\hat{T}_4$ 1982:2 (1981:3-1983:2)	$\hat{T}_5$ 1986:3 (1985:3-1987:4)	$\hat{T}_6$ 1996:3 (1995:1-1997:2)	$\hat{T}_7$ 2001:2 (2000:3-2002:4)	$\hat{T}_8$ 2008:2 (2008:1-2008:3)
		Regression coefficients							
		$\hat{\mu}_1$ 0.004 (0.002)	$\hat{\mu}_2$ -0.016 (0.003)	$\hat{\mu}_3$ 0.034 (0.003)	$\hat{\mu}_4$ 0.006 (0.001)	$\hat{\mu}_5$ 0.032 (0.002)	$\hat{\mu}_6$ 0.012 (0.001)	$\hat{\mu}_7$ -0.011 (0.002)	$\hat{\mu}_8$ 0.010 (0.001)
		$\hat{\mu}_9$ 0.072 (0.004)							

UK

Single structural break tests		**B&P test**					
A&Q test	A&P test	Break dates					
(p-value) 0.00	(p-value) 0.00	$\hat{T}_1$ 1986:3 (1984:2-1990:1)	$\hat{T}_2$ 1991:1 (1990:1-1991:3)	$\hat{T}_3$ 1997:1 (1996:2-1998:4)	$\hat{T}_4$ 2002:1 (2001:4-2003:3)	$\hat{T}_5$ 2007:3 (2005:2-2007:4)	
		Regression coefficients					
		$\hat{\mu}_1$ -0.002 (0.001)	$\hat{\mu}_2$ -0.022 (0.004)	$\hat{\mu}_3$ 0.026 (0.003)	$\hat{\mu}_4$ -0.010 (0.003)	$\hat{\mu}_5$ 0.015 (0.003)	$\hat{\mu}_6$ 0.057 (0.006)

Note: Dates in parentheses correspond to the 95% confidence intervals for the break dates, while values in parentheses are the standard errors that are robust to serial correlation.

3.2 Linearity Tests

As a final empirical exercise, we investigate the effect of structural breaks on the dynamics of public debt and assess whether the adjustment of the series is linear or nonlinear.

We test linearity against nonlinearity of threshold autoregressive (TAR) type, as cuts in public debt depend on government measures and political choice. Furthermore, they depend on the business cycle and, as a result, one can expect at least two regimes. In the first one, there is economic growth, which can induce a fall in public debt. In the second regime, the occurrence of economic crises leads to fiscal deficits, forcing governments to borrow more and, thus, to increase public debt.

Table 4 reports the results of the Hansen (1996) test which checks for threshold breaks, and the Tsay (1989) test which performs an arranged regression test for threshold

autoregression. They do not reject the nonlinearity hypotheses for the US and the UK public debt. Our findings also present strong evidence of switching-regimes in the dynamics of public debt. In fact, the change between regimes seems to have occurred in 2003:3 for the US and 2002:3 for the UK.

Table 4: Linearity tests

Tests	US	UK
Hansen (1996) threshold test	0.01	0.00
Tsay (1989) test	0.00	0.00

Note: The figures in the table refer to the *p*-values.

4. Conclusion

In this paper, we test for structural breaks and nonlinearity in the dynamics of the public debt in the US and the UK. We identify several structural breaks associated to economic downturns, oil shocks, and financial and political instability. Furthermore, we find evidence of nonlinearity and switching-regimes, in particular, since 2003 and close to the period of the Great Recession.

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