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Jingwen Fan and Michael G. Arghyrou

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Cardiff Business School
Cardiff University
Colum Drive
Cardiff CF10 3EU
United Kingdom
t: +44 (0)29 2087 4000
f: +44 (0)29 2087 4419
www.cardiff.ac.uk/carbs

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UK FISCAL POLICY SUSTAINABILITY, 1955-2006

Jingwen Fan*
(Cardiff University)

Michael G. Arghyrou
(Cardiff University)

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Abstract

We test for fiscal policy sustainability in the UK for the period 1955-2006. We find evidence of sustainability with three structural breaks, respectively occurring in the early 1970s, early 1980s and late 1990s. UK fiscal policy has been sustainable throughout the sample period except from 1973-1981 when a non-Ricardian regime applied. For the remaining periods correction of fiscal disequilibrium occurs through adjustments in public revenue rather than expenditure. Finally, we find evidence of non-linear fiscal adjustment, with UK authorities not reacting to relatively small deficits; but correcting exceedingly large deficits and any temporary surpluses relatively fast.

Keywords: Fiscal policy; Sustainability; UK; Structural breaks; Non-linear adjustment

JEL Classification: E62 H60

*Corresponding Author: Jingwen Fan, Cardiff Business School, Cardiff University, Colum Drive, Cardiff, CF10 3EU, UK. Tel: +44 (0)29 20876545. Email: jingwenfan6@gmail.com

1 Introduction

In recent months fiscal policy sustainability has returned to the forefront of policy debate. This follows the significant increase in many countries' public debt caused by the economic downturn following the global credit crunch and government-sponsored banking rescue plans. A country's fiscal policy is sustainable when its intertemporal government budget constraint (IBC) is met, implying that the stock of outstanding public debt is offset by expected future primary surpluses. Sustainable fiscal policy excludes the possibility of ponzi games where the government systematically services the cost of existing debt exclusively by issuing new one. Investors' willingness to hold the government's outstanding bonds depends on the latter's perceived ability to generate future surpluses by reducing excessive spending and/or increasing public revenue. Doubts regarding this ability will cause the government difficulties in marketing its debt (Quintos, 1995) and, after a critical threshold is surpassed, lead to a non-Ricardian, fiscal-dominance regime where the IBC is met through higher inflation rate reducing the real value of outstanding bonds, as suggested by the fiscal theory of the price level (see e.g. Leeper (1991), Woodford (1996, 1998a and 1998b)).

A country whose public finances have been hit particularly hard by the global financial crisis is the UK. In 2009, the UK deficit to GDP ratio reached the level of 11.5%, the highest among G7 members. This significant worsening of the UK's fiscal outlook, and continuing concerns regarding the UK's banking system fragile state, have raised concerns about the sustainability of the UK's triple A credit rating, causing a lively debate on the optimal extend and speed of fiscal adjustment. Existing studies suggest that the UK has a sound record in correcting fiscal imbalances, both historically (see e.g. Ahmed and Rogers, 1995) as well in recent years (see Considine and Gallagher, 2008). Given the increased current focus on fiscal policy, empirical evidence regarding the sustainability of UK budget finances is timelier than ever.

In this paper we revisit the question of UK fiscal policy sustainability from 1955 to the year preceding the onset of the fiscal downturn, 2006. Compared to existing studies, our analysis provides four distinct features. First, we test for fiscal policy sustainability accounting for structural shifts in UK fiscal policy, identified using tests for endogenous structural breaks. Second, we assess the sustainability of UK fiscal policy for each of the endogenously identified fiscal regimes. Third, we test whether deviations from the path of sustainable fiscal dynamics are corrected through adjustments in government revenue or expenditure. Finally, we test for non-linear adjustment in UK fiscal policy.

Our main findings can be summarized as follows: First, the UK fiscal policy has been sustainable over the period under examination. Second, it has been subject to three structural breaks, respectively located in the early 1970s, early 1980s and late 1990s. These dates coincide with important shifts in UK fiscal policy, with the first break moving government finances away from sustainability and the remaining two towards it. Third, fiscal policy was sustainable during all fiscal regimes, except from 1973-1981 when a non-Ricardian regime applied. Fourth, correction of deviations from fiscal sustainability has been taking place through adjustment of public revenue rather than expenditure. Finally, we find evidence of non-linearities in UK fiscal policy, with the UK government not reacting to relatively small deficit values; but correcting exceedingly large deficits and any temporary surpluses relatively fast.

Overall, our findings confirm the status of the UK government as a historically sound sovereign borrower; and suggest a fundamentally sound UK fiscal position at the eve of the credit crunch crisis. Given, however, the depth of the ensuing banking crisis and worsening of the UK's fiscal outlook, this does not leave any room for fiscal complacency. Having said so, our findings suggest is that in the coming years of fiscal consolidation UK authorities will more likely than not enjoy the markets' confidence in their historical ability to restore sustainability, even in the face of large fiscal shocks such as the present one. Within the current environment of increased risk aversion, and as the EMU sovereign debt crisis has amply demonstrated, such market credibility will be a significant advantage at the disposal of UK authorities striving to maintain sustainable fiscal dynamics.

The rest of the paper is organised as follows: in section 2 we review the relevant literature on testing government sustainability constraint; in section 3 we discuss the data; in section 4 we present the linear test of government budget sustainability; in section 5 we present the linear error correction models; in section 6 we analyse the issue of non-linear fiscal adjustment; section 7 concludes.

2 Previous Literature

Existing studies on fiscal policy sustainability mainly address three questions. The first, and main one, is whether fiscal policy is sustainable or not. The second is whether fiscal policy involves structural breaks. Finally, the third is whether fiscal adjustment involves non-linearities. A basic concept in this literature is the government's intertemporal budget constraint (IBC). To derive it Hakkio and Rush (1991) start from the standard government's budget constraint given by:

$$b_{t+1} = (1 + r_t)b_t + g_t - \tau_t \tag{1}$$

where b_t denotes the current stock of outstanding public debt in real values, r_t denotes the real interest rate, g_t denotes real government expenditure net of interest and τ_t is real tax revenues. Taking expectation and solving for b_t recursively we obtain

$$b_t = E_t \sum_{j=1} \frac{(\tau_{t+j} - g_{t+j})}{(1 + r)^{j+1}} + \lim_{j \longrightarrow \infty} E_t \left\{ \frac{b_{t+j+1}}{(1 + r)^{j+1}} \right\} \tag{2}$$

where E_t is the expectation operator. Equation (2) describes the government's IBC stating that the stock of outstanding public debt must be offset by the present value of expected future primary surpluses. For this condition to be met the transversality condition $\lim_{j \longrightarrow \infty} E_t \left\{ \frac{b_{t+j+1}}{(1+r)^{j+1}} \right\} = 0$ must hold. This rules out ponzi schemes i.e. the possibility of servicing government debt by issuing increasing new debt. Tests of fiscal policy sustainability aim to determine whether the limit term in equation (2) converges to zero or infinity, respectively denoting sustainable and unsustainable public debt dynamic.

Such tests, focusing mainly but not exclusively on the United States, can be broadly grouped into two categories. The first applies unit root tests on government deficit and/or discounted debt series, with unit roots interpreted as evidence of unsustainable fiscal dynamics. The early studies by Hamilton and Flavin (1986) and Hakkio and Rush (1986) assume constant real interest rates and argue that a sufficient condition for the IBC to be met is for the government deficit net of interest payments to be stationary. Both studies reject the null of unit root for US real deficit and debt for the period 1960-1984 and 1962-1985 respectively. Trehan and Walsh (1988) argue that the only necessary and sufficient condition for the IBC to be met is for the deficit series inclusive of interest payments to be statinonary. Using this criterion they find US public finances to be sustainable over the period 1890-1986. Kremers (1989) applies unit root tests on government debt-to-GNP and interest-to-GNP ratios. He finds US fiscal policy to be sustainable for most of the inter- and post-war period but not sustainable after 1981. Wilcox (1989) introduces stochastic real interest rates. He argues that the IBC may be satisfied even if the level of the primary debt is non-stationary; and that the sufficient condition for sustainability is for the discounted value of public debt to converge to zero. Using this criterion, he finds US fiscal policy to be unsustainable for the post-1974 period.[1]

[1]Other studies adopting this approach include Féve and Hénin (2000) and Uctum and Wickens (2000). Féve and Hénin (2000) use semi-annual data and test for fiscal policy sustainability for G7 countries, con-

The second category applies tests for cointegration between public deficit and debt or, more frequently, government expenditure and government revenue. Haug (1991) tests for cointegration between real government debt and real surplus using quarterly US data over the period 1960-1986. He finds evidence of cointegration suggesting sustainable US fiscal policy. MacDonald (1992) provides a similar analysis for the period 1951-1984. Using monthly data, he reaches the opposite conclusion. On the other hand, Hakkio and Rush (1991) test for cointegration between US real per capita government revenue and expenditure using quarterly data for the period 1950-1988. Their cointegration regression is given by equation (3) below

$$R_t = \alpha + \beta G_t + \varepsilon_t \tag{3}$$

where R_t and G_t respectively denote the logs of real government revenue and government expenditure including interest on outstanding debt and ε_t is a random error term. Hakkio and Rush (1991) assume stochastic real interest rates and argue that for fiscal policy to be sustainable public revenue and expenditure should be cointegrated with $\beta = 1$. Using the entire sample period, they find these conditions to be met. However, they find US fiscal policy not to be sustainable following 1964, with evidence of non-cointegration being particularly strong during the period 1976 -1988. Using the same cointegration methodology, Ahmed and Rogers (1995) conclude that UK fiscal policy is sustainable over the period spanning over two centuries. Corsetti and Roubini (1991) provide a similar analysis for selected EMU countries finding that their government finances do not satisfy the IBC.[2]

Tests of fiscal policy sustainability based on cointegration tests are subject to biased inference in case the underlying cointegrating relationship is subject to structural breaks. Hakkio and Rush (1991), MacDonald (1992) and Haug (1995) address structural instability by choosing the break dates exogenously. By contrast, Quintos (1995) uses tests determining the break dates endogenously. She also introduces the concepts of strong- and weak-form fiscal policy sustainability. Her definitions encompass and extend previous definitions. In view of the generality of her approach we adopt it for our own econometric investigation below. Strong-form sustainability is equivalent to the sustainability definition used by Hamilton and

cluding that a unit root cannot be rejected for Germany, France, Italy and Canada. Uctum and Wickens (2000) use annual data over the period 1965-1994 testing for fiscal sustainability in the US and eleven EU countries. They conclude that only Denmark, the Netherlands, Ireland and France were on a sustainable fiscal path.

[2] Other studies using a cointegration framework to test the validity of the IBC in Europe include Bravo and Silvestre (2002) and Afonso and Rault (2010) for eleven and fifteen EU countries respectively. Both studies reach mixed results with regards to the validity of the IBC in their sample countries.

Flavin's (1986) and Hakkio and Rush (1991). Under weak-form sustainability the limit term in equation (2) converges to zero but at rate lower compared to the strong-form sustainability case. Furthermore, under weak-form sustainability the limit term in equation (2) converges to zero faster when government revenue and expenditure are cointegrated rather than when they are not. Weak form sustainability implies that the level series of deficit and undiscounted debt may be mildly explosive, in which case an unpredictable adverse shock may put public finances into an unsustainable path. As a result, under weak-form sustainability the government may face difficulties marketing its debt and be obliged to pay higher interest rates to service it. In terms of equation (3) fiscal policy is weak-form sustainable if $0 < \beta < 1$, irrespective of whether R_t and G_t are cointegrated or not; weak-form sustainable if $\beta = 1$ and R_t and G_t are non-cointegrated; strong form sustainable if $\beta = 1$ and R_t and G_t are cointegrated; and non-sustainable if $\beta = 0$. Quintos applies her methodology to US quarterly data covering the period 1947-1992. She concludes that the US fiscal policy is weakly sustainable despite a negative structural break in the early 1980s causing non-cointegration after 1980.

Arghyrou and Luintel (2007) use Quintos's methodology to test for fiscal policy sustainability in four heavily indebted EMU countries, namely Greece, Ireland, Italy and the Netherlands. They find that the introduction of the Maastricht Treaty in 1991 has caused a structural break towards sustainability; and that fiscal policy at the eve of the euro's introduction in 1999 was strong-form sustainable in Ireland and weak-form sustainable in the rest of their sample countries. Finally, they find evidence of non-linear fiscal adjustment, which is consistent with the findings of Bohn (1998), Cipollini (2001), Sarno (2001), Arestis et al (2004), Bajo-Rubio et al (2004, 2006), Chortareas et al (2008), Considine and Gallagher (2008) and Cipollini et al (2009) for a host of different countries. These studies model the dynamics of the discounted public debt series or the cointegrating vector between public revenue and expenditure in a number of different countries using variants of threshold autoregressive (TAR) models. The intuition underlying these non-linear models is that fiscal adjustment takes place more rapidly when budget deficits or the stock of outstanding debt exceed certain critical thresholds beyond which they are considered exceedingly large.

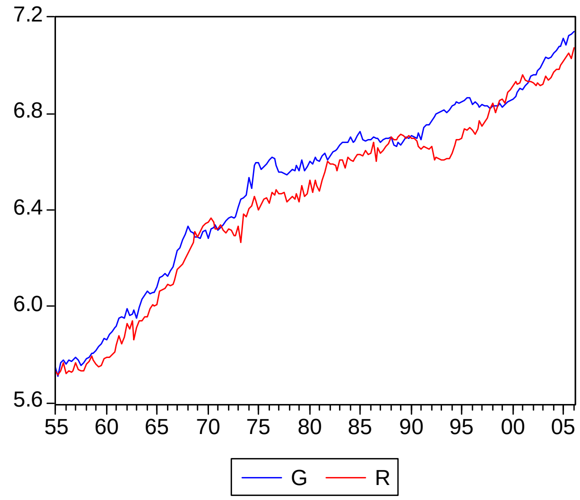

Figure 1: Real government revenue and expenditure (both in log terms)

3 Data

For our econometric investigation we use data for UK total managed public expenditure inclusive of interest payments on outstanding public debt and total public revenue excluding seignorage. Our data source is the UK Office of National Statistic (ONS) data bank. The data frequency is quarterly and covers the period 1955Q1-2006Q1. We calculate real government revenue R_t and real government expenditure G_t deflating nominal series by the GDP deflator. Figure 1 plots the de-seasonalised data in log real terms.[3] Table 1 reports unit root tests on the series' log-levels and first differences. Both series are integrated of order one and show a similar upward trend. However, there appears to be significant divergence during the 1970s and 1980s, indicating increasing deficits over those periods and structural breaks in any cointegrating relationship that may link the two series. Both the Augmented Dickey Fuller (ADF) (1979, 1981) and Phillips-Perron (PP) (1988) tests confirm that government revenue and expenditure are first difference stationary (see Table 1).

[3]The original data series include strong seasonal effects which we account for using a constant and three seasonal dummies.

Unit Root Tests	G_t		R_t	
	Levels	1^{st}. Diff.	Levels	1^{st}. Diff.
ADF Test Statistic	-1.744	-5.643	-1.086	-6.755
	0.408	0.000**	0.722	0.000**
PP Test Statistic	-1.274	-16.490	-0.848	-18.261
	0.642	0.000**	0.803	0.000**

Table 1: Unit root test for deseasonalised Government expenditure G and revenue R

Notes on Table: MacKinnon's critical values (MacKinnon, 1996) for rejection of hypothesis of a unit root: values in parentheses are p-values, while ** indicates significance at the 1% level. The number of lags in the ADF tests is set using the AIC criterion; for the PP tests using the Newey-West bandwidth.

4 Linear tests on fiscal policy sustainability

We start our econometric investigation on the sustainability of UK fiscal policy using the linear cointegration framework discussed in section 2 above. We first test for sustainability without accounting for structural breaks in the cointegrating equation given by (3). We use Dynamic OLS (DOLS) a cointegration method that is asymptotically equivalent to the Engle and Granger (1987) and Johansen (1988) cointegration methodologies with the extra advantages of performing better in small samples and controlling for endogeneity among the regression's variables through the inclusion of lead and lag differences of the regressors (see Stock and Watson, 1993). Given that both series include one unit root, the DOLS regression is given by equation (4) below

$$R_t = \alpha + \beta G_t + \sum_{t=-k}^{k} \gamma_k \Delta G_{t-k} + \varepsilon_t \tag{4}$$

where Δ denotes the first difference operator and ε_t is a random error term. If the residual series ε_t is serially correlated, we estimate (3) using the Dynamic Generalised Least Squares (DGLS) estimator. This augments equation (4) with autoregressive error terms under the Feasible Generalised Least Squares. Under both DOLS and DGLS the cointegrating vector is given by $CV = R_t - \widehat{\alpha} - \widehat{\beta} G_t$. The results of estimating equation (3) using DGLS are reported in Table 3 below. Although the restriction $\beta = 1$ is not rejected, strong-from sustainability is rejected as the reported ADF test is not significant at the 5% level.

Cointegration Analysis without breaks	
	DGLS
	1955Q1-2006Q1
Estimated equation	
$R_t = \alpha + \beta G_t + \varepsilon_t$	
$\widehat{\alpha}$	0.044(0.128)
$\widehat{\beta}$	0.984(0.020)**
F-Wald test, $H_0 : \widehat{\beta} = 0$ [p-value]	2443.31[0.000]**
F-Wald test, $H_0 : \widehat{\beta} = 1$ [p-value]	0.609[0.435]
t-ADF test on $\widehat{\varepsilon}_t$	-2.693
5% critical value	[-2.876]
S.E.of regression	0.055

Table 2: Cointegrating test for government revenue and expenditure

Notes on Table: standard errors in parentheses. ** indicate significance at the 1% level. All DGLS estimates are corrected for heteroskedasticity and autocorrelation of unknown form in the residuals (DOLS-HAC, see Newey and West, 1987).

Rejection of cointegration, however, may be due to structural breaks in the cointegrating relationship given by (3). To identify such breaks endogenously we use the sequential cointegration stability test proposed by Quintos (1995) described by equations (5) to (7) below

$$R_t = \alpha + \beta G_t + \delta(D_t G_t) + \varepsilon_t \tag{5}$$

where,

$$D_t = 1 \text{ if } t \in T_1 = \{1, ..., m\} \tag{6}$$

$$D_t = 0 \text{ if } t \in T_2 = \{m+1, ..., T\} \tag{7}$$

In equations (6) and (7) D_t is a dummy variable taking the value of unity before period m and zero thereafter, where m represents the date of the tested breakpoint. The null hypothesis of stability assumes $\delta = 0$ and is tested using a Wald F-test. Equation (5) is estimated sequentially. Following Andrews (1993) we have trimmed 15 per cent from the beginning and the end of the sample. We estimate equation (4) using DOLS and, for robustness, OLS. Figure 2 plots the sequential Wald test statistics testing the restriction $\delta = 0$ over the period of 1963Q -1998Q4. Figure 2 suggests that the cointegrating relationship between R_t and G_t has been subject to multiple structural breaks. More specifically, it

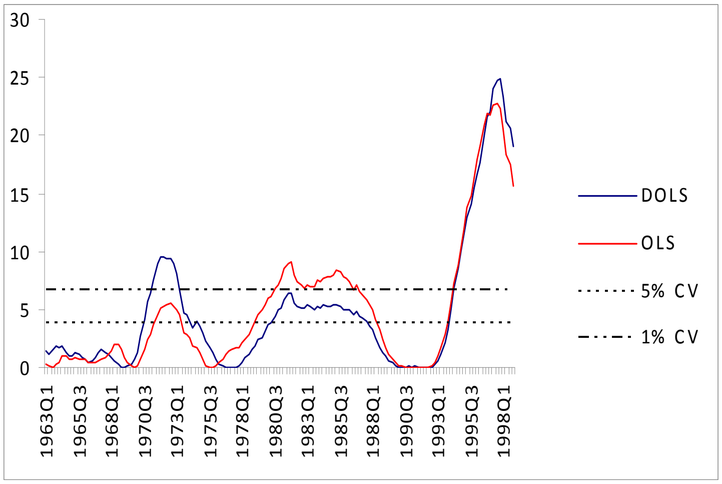

Figure 2: Sequential Wald tests for structural breaks

suggests a number of statistically significant values for the depicted Wald statistics in the early 1970s, the early 1980s and the second half of the 1990s. As structural breaks cannot fall too close together, these three groupings of statistically significant values are very likely reflecting three distinct structural breaks. We define the exact timing of each of the three breaks on the basis of highest F-score in each grouping. Using this criterion, both estimators suggest breaks of almost identical timing, with DOLS suggesting the break points to be 1972Q3, 1981Q3 and 1997Q4, while OLS suggests 1972Q1, 1981Q4 and 1997Q3. These dates can be related to important exogenous shifts in UK macroeconomic policy. The break in 1972 is close to the introduction of UK expansionary fiscal policies targeting the unemployment rate through wage and income controls. The break in 1981 coincides with the introduction of the fiscal consolidation effort pursued by the Medium Term Financial Strategy (MTFS), a monetary and fiscal policy programme announced by the Conservative Government in late 1980. Finally, the break date in 1997 is close to the endorsement of the then newly-elected Labour government of its predecessor's relatively restrictive fiscal policies and the granting of operational independence to the Bank of England, establishing further the "monetary-dominance" rather than "fiscal-dominance" nature of the UK macroeconomic outlook.

Our next step is to test for UK fiscal policy sustainability accounting for the effect of the structural breaks identified above. We do so by estimating equation (8) below

$$R_t = \alpha + \beta G_t + \sum_{i=1}^{j} \phi_i (D_{it} G_t) + \varepsilon_t \tag{8}$$

Equation (8) modifies the cointegrating regression given by equation (3) by including slope dummy variables corresponding to each of the three breaks identified above. Each of the three dummies D_{it} ($j = 1, 2, 3$) takes a zero value before the date of the corresponding break and the value of unity thereafter (see Table 3). A positive (negative) coefficient represents a movement towards (away from) the strong-form sustainability. The augmented cointegrating vector obtained by equation (8) is then given by

$$CV = R_t - \alpha - \beta G_t - \sum_{i=1}^{3} \phi_i (D_{it} G_t) \tag{9}$$

We estimate (8) using three alternative methodologies, namely DGLS, DOLS and simple OLS. The break dates for the DGLS/DOLS and OLS estimates of equation (8) are respectively defined on the basis of the highest score obtained from the DOLS and OLS estimator for each grouping of statistically significant F-statistics in Figure 2. The only exception is the break of the early 1970s when equation (8) is estimated using the DGLS methodology. By defining D_{1t} to take the value of unity after 1972Q3 we could not obtain DGLS estimates free of heteroskedasticity problems and obtained a marginally insignificant, at the 5% level, dummy coefficient. Experimenting with alternative definitions of D_{1t} in the neighbourhood of 1972Q3 we obtained the best data representation (in terms of a minimum score for the Akaike information criterion and regression standard error) when D_{1t} took the value of unity from 1973Q3 onwards.

The results of our estimations are reported in Table 3. The coefficients of all break dummies turn out to be statistically significant at the 5% level with the expected signs. More specifically, the coefficient of the dummy capturing the break of the early 1970s is in all cases negative suggesting a deteriorating fiscal outlook during the implementation of the fiscal expansion of that period. The positive and significant coefficients of the dummies capturing the break of the early 1980s confirm the partial reversal of the expansionary dynamics established in the early 1970s. Finally, the dummy variables capturing the break of 1997 have a positive and significant coefficient, suggesting further improvement of the UK's public finances over the period 1998-2006.

Finally, we use the findings reported in Table 3 to test for weak and strong-form sustainability. Unlike the findings reported in Table 2, the DGLS results reported in Table 3 suggest cointegration between government revenue and expenditure at the 5% level, while the DOLS and OLS results suggest cointegration at the 6% level. As the DGLS model produces a significantly lower regression standard error, it seems to provide the best data representation. We then test the null hypothesis of a unity total multiplier for the coefficient of public expenditure, given by $H_0 : \beta + \sum_{j=1}^{k} \phi_j = 1$,for $j = 1, 2, 3$. For the DGLS and DOLS estimates the null of a unity total multiplier is maintained. This, combined with the finding of cointegration in our prefered DGLS estimation, suggests that following the structural breaks that occurred in the early 1970s, 1980s and late 1990s, over the period 1955-2006 UK fiscal policy was on a path of strong-form sustainability.

Cointegration Analysis with breaks			
	DGLS	DOLS	OLS
Estimated equation			
$R_t = \alpha + \beta G_t + \phi_1 D_1 G_t + \phi_2 D_2 G_t + \phi_3 D_3 G_t + \varepsilon_t$			
$\widehat{\alpha}$	0.014(0.253)	0.161(0.165)	0.323(0.154)*
$\widehat{\beta}$	0.997(0.042)**	0.968(0.027)**	0.939(0.025)**
$\widehat{\phi}_1(D_1 = 1$ in 1972Q1-2006Q1, 0 Otherwise)	-	-	-0.006(0.003)*
$\widehat{\phi}_1(D_1 = 1$ in 1972Q3-2006Q1 0 Otherwise)	-	-0.008(0.003)**	-
$\widehat{\phi}_1(D_1 = 1$ in 1973Q3-2006Q1, 0 Otherwise)	-0.015(0.004)**	-	-
$\widehat{\phi}_2(D_2 = 1$ in 1981Q3-2006Q1, 0 Otherwise)	0.007(0.003)*	0.005(0.002)**	-
$\widehat{\phi}_2(D_2 = 1$ in 1981Q4-2006Q1, 0 Otherwise)			0.007(0.002)**
$\widehat{\phi}_3(D_3 = 1$ in 1997Q3-2006Q1, 0 Otherwise)	-	-	0.009(0.002)**
$\widehat{\phi}_3(D_3 = 1$ in 1997Q4-2006Q1, 0 Otherwise)	0.013(0.005)**	0.010(0.002)**	
F-Wald test, $H_0 : \widehat{\beta} + \widehat{\phi}_1 + \widehat{\phi}_2 + \widehat{\phi}_3 = 0$ [p-value]	741.71[0.000]**	1688.07[0.000]**	1844.40[0.000]**
F-Wald test, $H_0 : \widehat{\beta} + \widehat{\phi}_1 + \widehat{\phi}_2 + \widehat{\phi}_3 = 1$ [p-value]	0.001[0.981]	1.040[0.309]	5.193[0.024]*
t-ADF test on $\widehat{\varepsilon}_t$	-2.880*	-2.837	-2.851
5% critical value	[-2.876]	[-2.876]	[-2.876]
S.E.of regression	0.021	0.047	0.050

Table 3: Cointegration analysis with endogenous structural breaks

Notes on Table: standard errors in parentheses. *, ** indicate significance at the 5% and 1% level, respectively. All DGLS estimates are corrected for heteroskedasticity and autocorrelation of unknown form in the residuals (DOLS-HAC, see Newey and West, 1987).

5 Linear error correction models

In the previous section we concluded that the post-war UK fiscal policy has been subject to three structural breaks, giving rise to four fiscal regimes over the sample period respectively covering the periods 1955-1972; 1973-1981; 1982-1997 and 1998-2006. In this section we estimate linear error correction models (ECM) for each of these periods with a dual objective. First, to establish whether fiscal policy reacts to fiscal disequilibrium as the latter is captured by the cointegrating vector accounting for structural breaks. If for a particular period the disequilibrium term enters the ECM with an insignificant coefficient or a significant coefficient of positive sign, then the fiscal regime of that period is identified as 'non-Ricardian', characterized by non-sustainable fiscal policy. Second, if fiscal policy reacts to deviations from the long-run equilibrium path, estimates of ECMs will provide us information as to whether the adjustment comes through the revenue or expenditure side, or both. A system of two dynamic Error Correction Model (ECM) can be respectively written as

$$\Delta R_t = \alpha + \sum_{i=1}^{k} \beta_i \Delta R_{t-k} + \sum_{i=1}^{k} \gamma_i \Delta G_{t-k} + \delta \widehat{\varepsilon}_{t-1} + v_t \quad (10)$$

$$\Delta G_t = \alpha + \sum_{i=1}^{k} \beta_i \Delta R_{t-k} + \sum_{i=1}^{k} \gamma_i \Delta G_{t-k} + \delta \widehat{\varepsilon}_{t-1} + v_t \quad (11)$$

where, $\widehat{\varepsilon}_{t-1}$ is the estimated cointegrating vector, obtained from the DGLS estimation of equation (8)accounting for structural break and v_t is a random error.

The results of our ECM estimations are reported in Table 4. The Table presents ECM models estimated for the whole of our sample period as well as for each of the four sub-periods defined by structural breaks identified in section 4 above. For each sample period we present two ECMs, ECM1 and ECM2, respectively defining the dependent variable to be ΔR_t and ΔG_t. We report parsimonious estimates (i.e. excluding insignificant terms) obtained from initial models including four lags (i.e. $k = 4$) of ΔR_t and ΔG_t. For the full-sample period and three out of four sub-periods, the coefficient of the error correction term δ is statistically significant with a negative sign in the equation modeling ΔR_t and not significant in the equation modeling ΔG_t. These findings suggest a Ricardian regime, consistent with fiscal policy sustainability and adjustment to any fiscal disequilibrium coming from the revenue rather than expenditure side. This is an indication of UK authorities relying more on tax increases rather than expenditure reductions to correct fiscal imbalances. On the other hand, the period 1973Q3-1981Q2 seems exceptional. For that period, the δ coefficient is insignificant in both ECM equations, suggesting lack of policy reaction to the increasing at the time fiscal disequilibrium term. This is consistent with our findings in the previous section, suggesting a structural shift away from fiscal sustainability in the early 1970s and the presence of a non-Ricardian regime in the 1970s.

ECM(1) DepV:ΔR_t	1955Q1-2006Q1	1955Q1-1973Q2	1973Q3-1981Q2	1981Q3-1997Q3	1997Q4-2006Q1
$\widehat{\delta}$	-0.131(0.031)**	-0.258(0.050)**	-0.249(0.170)	-0.095(0.042)*	-0.110(0.049)*
$\widehat{\alpha}$	0.005(0.002)**	-	-	0.006(0.003)*	-
$\widehat{\beta}_1$	-0.291(0.065)**	-	-0.488(0.141)**	-0.290(0.109)**	-
$\widehat{\beta}_2$	-	-	-	-	-
$\widehat{\beta}_3$	0.164(0.062)**	-	-	-	-
$\widehat{\beta}_4$	-	-	-	-	-
$\widehat{\gamma}_1$	-0.191(0.091)*	-0.329(0.137)*	-	-	-
$\widehat{\gamma}_2$	-	-	-	-	-
$\widehat{\gamma}_3$	-	-	0.414(0.183)*	-0.349(0.173)*	-
$\widehat{\gamma}_4$	-	-		-0.341(0.173)*	-
S.E.of regression	0.022	0.021	0.027	0.021	0.020
Misspe. tests (p-values)					
F-AR	0.91	0.68	1.00	0.29	0.18
F-$ARCH$	0.12	0.88	0.27	0.77	0.80
Normality	0.40	0.23	0.84	0.30	0.91
F-Het	0.44	0.16	0.07	0.72	0.21
ECM(2) DepV:ΔG_t	1955Q1-2006Q1	1955Q1-1973Q2	1973Q3-1981Q2	1981Q3-1997Q3	1997Q4-2006Q1
$\widehat{\delta}$	-0.040(0.023)	-0.035(0.051)	0.141(0.121)	-0.003(0.030)	-0.033(0.037)
$\widehat{\alpha}$	0.007(0.001)**	0.010(0.003)**	-	0.004(0.002)*	0.014(0.003)**
$\widehat{\beta}_1$	-	-	-	-	-
$\widehat{\beta}_2$	-	-0.215(0.088)*	-	-	-0.258(0.109)*
$\widehat{\beta}_3$	-	-	-0.291(0.132)*	-	-
$\widehat{\beta}_4$	-	-	-	-	-
$\widehat{\gamma}_1$	-0.219(0.066)**	-	-	-	-0.486(0.153)**
$\widehat{\gamma}_2$	-	-	0.376(0.171)*	-	-
$\widehat{\gamma}_3$	-	-	0.376(0.179)*	-	-
$\widehat{\gamma}_4$	-	-	-	-	-
S.E.of regression	0.017	0.018	0.026	0.015	0.011
Misspe. tests (p-values)		-			
F-AR	0.57	0.76	0.10	0.45	0.99
F-$ARCH$	0.10	0.81	0.38	0.44	0.28
Normality	0.32	0.75	0.61	0.20	0.46
F-Het	0.77	0.40	0.06	0.49	0.54

Table 4: Error correction model for short run dynamic behaviours

Notes on Table: standard errors in parentheses. *, ** indicate significance at the 5% and 1% level, respectively. Some estimations include impulse dummy variables for outlier observations. These are: for period 1955Q1-2006Q1, 1962Q4 in ECM(1) and 1974Q1 and 1974Q3 in ECM(2); for period 1955Q1-1973Q2, 1962Q4 in ECM(1). The estimates for period 1973Q3-1981Q2 are corrected for heteroskedasticity and autocorrelation of unknown form in the residuals (OLS-HAC estimates). F-AR is the Lagrange Multiplier F-test for residual serial correlation up to forth order. $F\text{-}ARCH$ is an F-test for autoregressive conditional heteroskedasticity. Norm is the normality chi-Square Bera-Jarque test for residuals' non-normality. F-Het is F-test for residuals heteroskedasticity.

6 Non-linear fiscal adjustment

We conclude our econometric analysis by testing for non-linear adjustment in UK fiscal policy. The basic intuition underlying non-linear fiscal policy is that the government corrects excessive deficits at a rate faster than "normal" ones, which are corrected at a lower speed, or perhaps not corrected at all. The hypothesis of linear fiscal policy can be tested using the testing procedure by Granger and Teräsvirta (1993) and Teräsvirta (1994). This is based on the auxiliary regression given by equation (12) below

$$\widehat{\varepsilon}_t = \gamma_{00} + \sum_{j=1}^{\phi} \left(\gamma_{0j}\widehat{\varepsilon}_{t-j} + \gamma_{1j}\widehat{\varepsilon}_{t-j}\widehat{\varepsilon}_{t-d} + \gamma_{2j}\widehat{\varepsilon}_{t-j}\widehat{\varepsilon}^2_{t-d} + \gamma_{3j}\widehat{\varepsilon}_{t-j}\widehat{\varepsilon}^3_{t-d} \right) + \gamma_4\widehat{\varepsilon}^2_{t-d} + \gamma_5\widehat{\varepsilon}^3_{t-d} + \omega_t \quad (12)$$

In (12) ε_t denotes the estimated fiscal disequilibrium term accounting for structural breaks given by the estimated residuals obtained from the DGLS estimation of equation (8); ϕ is the order of the autoregressive parameter determined by the partial autocorrelation function of ε_t (see Granger and Teräsvirta(1993)); d is the delay parameter of the transition function; and ω_t is an the error term with Gaussian distribution. The null hypothesis of linearity is described by $H_0 : \gamma_{1j} = \gamma_{2j} = \gamma_{3j} = \gamma_4 = \gamma_5 = 0$, for all $j \in (1, 2, ...\phi)$. This is tested using a general LM-type test, denoted by LM^G, estimated for all plausible values of d. If any of the LM^G statistics is statistically significant the linearity hypothesis is rejected. If more than one LM^G statistics are significant the value of d is determined by the highest F-score. If linearity is rejected we determine the specific form of non-linearity following the approach by Teräsvirta and Anderson (1992). In terms of equation (12) this involves three steps. First, conditional upon LM^G being significant we test the null described by $H_0 : \gamma_{3j} = \gamma_5 = 0$, for all $j \in (1, 2, ...\phi)$. This test is denoted as LM^{L1}. If LM^{L1} is significant we conclude that non-linearity is of the logistic form. If LM^{L1} is not significant we test

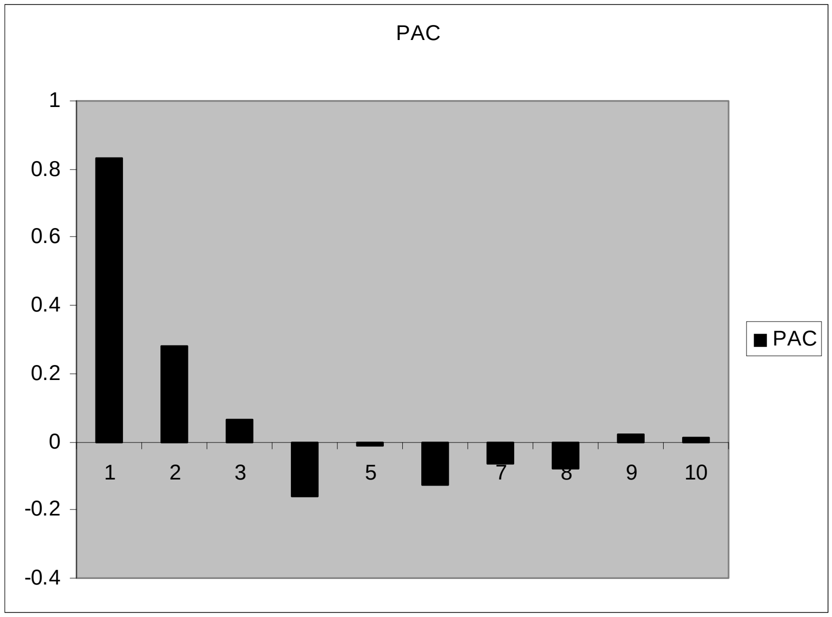

Figure 3: Partial autocorrelation function (CV accounts for structural breaks, 1955-2006)

the null of $H_0 : \gamma_{1j} = \gamma_{2j} = \gamma_4 = 0|\gamma_{3j} = \gamma_5 = 0$,for all $j \in (1, 2, ...\phi)$. We denote this test as LM^Q. If LM^Q is significant we conclude that non-linearity is quadratic. If both LM^{L1} and $LM^{\dot{Q}}$ are insignificant we perform a third test, LM^{L2}, where the null is given by $H_0 : \gamma_{1j} = 0|\gamma_{2j} = \gamma_{3j} = \gamma_4 = \gamma_5 = 0$,for all $j \in (1, 2, ...\phi)$. A statistically significant LM^{L2} indicates linearity of the logistic type.

Given the relatively small number of observations in each of the fiscal regimes identified in the previous section we test for non-linear fiscal adjustment using the whole of the available sample period. Figure 3 presents the partial autocorrelation function of the series obtained from estimating equation (8) with DGLS, i.e. the DGLS estimates of the cointegrating vector accounting for structural breaks. This is statistically significant up to the second lag, therefore we estimate (12) setting $\phi = 2$.

The results of the non-linearity tests are reported in Table 5. We report findings for d = 1, 2, 3 and 4. We obtain a significant LM^G score for d=1, thus rejecting the hypothesis of linear fiscal adjustment. For d=1 the LM^{L1} and LM^Q are insignificant and significant respectively. Therefore, we conclude the existence of non-linearity of quadratic type. This implies the existence of two fiscal regimes, defined by an upper and lower critical deficit threshold value. Deficit values within the critical thresholds belong to the inner regime, interpreted as normal deficit values. Deficit values below the lower critical threshold denote an exceedingly large fiscal deficit, calling for more aggressive correction. Finally, deficit values above the upper critical threshold denote an exceptionally small deficit value, or a surplus, which fiscal authorities may use as a cushion allowing a fast increase in spending and/or reduction in taxation, bringing the deficit back into its normal range.

$\phi = 2$

d	LM^{G}	LM^{L1}	LM^{Q}	LM^{L2}
1	7.523[0.000]**	1.717[0.182]	13.775[0.000]**	N/A
2	0.989[0.434]	1.321[0.269]	1.073[0.362]	0.064[0.801]
3	1.151[0.335]	2.115[0.124]	1.057[0.350]	0.265[0.767]
4	0.522[0.791]	1.130[0.325]	0.277[0.759]	0.161[0.852]

Table 5: Test for non-linear fiscal adjustment

Notes on Table: The p-value are in square brackets, ** represents significance at 1% level.

We model quadratic non-linearity using the Quadratic-Logistic Smooth Threshold Error Correction Model(QL-STECM). This is given by equations(13) to(16)below

$$\Delta R_t = \theta_t S_{1t} + (1-\theta_t) S_{2t} + v_t \tag{13}$$

$$S_{1t} = \alpha_1 + \sum_{i=1}^{n} \beta_{1i} \Delta R_{t-i} + \sum_{i=0}^{p} \gamma_{1i} \Delta G_{t-i} + \delta_1 \widehat{\varepsilon}_{t-1} \tag{14}$$

$$S_{2t} = \alpha_2 + \sum_{i=1}^{n} \beta_{2i} \Delta R_{t-i} + \sum_{i=0}^{p} \gamma_{2i} \Delta G_{t-i} + \delta_2 \widehat{\varepsilon}_{t-1} \tag{15}$$

$$\theta_t = pr\left\{\tau^L \leqslant \widehat{\varepsilon}_{t-d} \leqslant \tau^U\right\} = 1 - \frac{1}{1 + e^{-\sigma(\widehat{\varepsilon}_{t-d} - \tau^L)(\widehat{\varepsilon}_{t-d} - \tau^U)}} \tag{16}$$

Equations (14) and (15) are standard linear error-correction models, capturing the two fiscal regimes, the inner (S_1) and the outer (S_2). Within the inner regime adjustment towards equilibrium takes place at a speed described by δ_1. At the outer regime, adjustment takes place at a rate equal to δ_2. Our expectation is that $|\delta_2| > |\delta_1|$ denoting faster adjustment in the outer rather than the inner regime. Equation(13) models period-to-period fiscal adjustment as a weighted average of S_1 and S_2. The regime weight θ_t is defined in (16) as the probability that the transition variable ε_{t-d} takes values within the inner regime boundaries, with σ denoting the speed of transition between these two regimes.

The estimates of the parsimonious QL-STECM model are reported in Table 6. The estimated coefficient of the error correction term in the inner regime (S_1) is insignificant, suggesting no correction of deficits. By contrast, the coefficient of the error correction term in the outer regime (S_2) is significant, with both critical thresholds τ^U and τ^L being negative and significant. These suggest correction of excessive large deficits. They also suggest that UK governments correct (push back into the inner regime) any temporary small deficits and surpluses.[4] The QL-STECM has good econometric properties, as it passes all misspecification tests. It also fits the data better than its linear counterpart reported in the first column of Table 4, as suggested by its lower regression standard error.

	S_1	S_2
Constant	0.028(0.012)*	-0.001(0.002)
ΔG_t	-	0.440(0.097)**
ΔR_{t-1}	-0.336(0.139)*	
ΔR_{t-5}	-	0.204(0.077)**
$\widehat{\varepsilon}_{t-1}$	0.564(0.361)	-0.122(0.029)**
σ	768.64(929.9)	
τ^U	-0.012(0.003)**	
τ^L	-0.053(0.003)**	
S.E.of regression	0.021	
Misspecification tests (p-values)		
F-AR	0.42	
F-$ARCH$	0.21	
Norm	0.55	
F-Het	0.73	

Table 6: Non-linear fiscal adjustment model QL-STECM

Notes on Table: Standard errors in parentheses. *,** denote significance at 5% and 1% level respectively. The model has been estimated using two dummy variables for outlier observations, in 1962Q4 and 1973Q2 respectively. F-AR is the Lagrange Multiplier F-test for residual serial correlation up to fourth order. F-$ARCH$ is an F-test for autoregressive conditional heteroskedasticity. Norm is the normality chi-square Bera-Jarque test for residuals' non-normality. F-Het is an F-test for residual heteroskedasticity.

[4]These findings are consistent with those reported by Considine and Gallagher (2008), who base their analysis on non-linearities indentified for the UK debt to GDP ratio series.

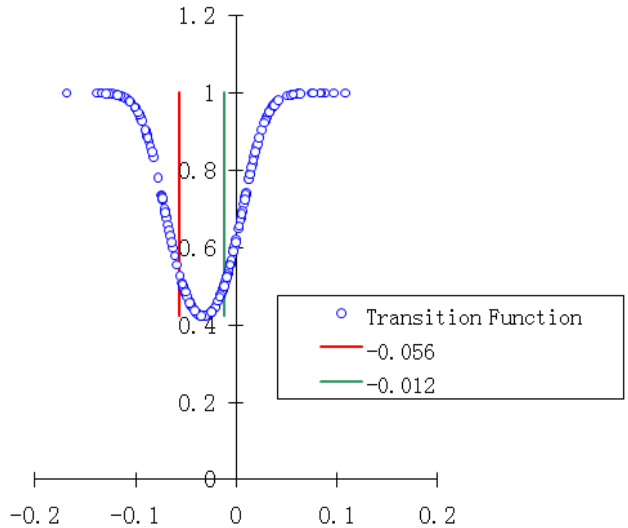

Figure 4: Estimated transition function

Figure 4 plots the transition function $\theta(\varepsilon_t; \sigma, \tau)$, i.e. the probability of a regime change in the current period against the transition variable ε_{t-1}, the value of fiscal disequilibrium in the previous period. We would intuitively expect $\theta(\varepsilon_t; \sigma, \tau)$ to increase as the fiscal outlook deteriorates beyond the lower deficit threshold, calling for a fast correction of deficits; or increases above the upper deficit threshold, providing the government the opportunity to introduce higher expenditure or reduce taxation. In both cases we would expect a high value of $\theta(\varepsilon_t; \sigma, \tau)$ capturing a high probability of a transition from the outer regime to the inner. By contrast, when the fiscal disequilibrium term takes values within the inner regime, we would expect a low value for $\theta(\varepsilon_t; \sigma, \tau)$, denoting a low probability of switching from the inner regime to the outer. Figure 4 provides evidence consistent with our expectations. As expected, the probability of regime change is lowest when the transition variable takes its mean value (-0.026) which lies comfortably within the inner regime defined by [-0.056, -0.012]. On the other hand, the probability of a switch from the outer to the inner regime convergences to unity fast as the lagged disequilibrium term moves away from the model's estimated critical thresholds.

Finally, Figure 5 depicts the estimated θ_t parameter over our sample period and its smoothed two-year moving average value. The value of θ_t denotes the probability of being in the inner regime, i.e. expectations of being in the regime of 'normal', and by implication sustainable, deficit values. From that point of view it can be seen as a rough measure of credibility of the current fiscal policy stance providing an indication regarding expectations

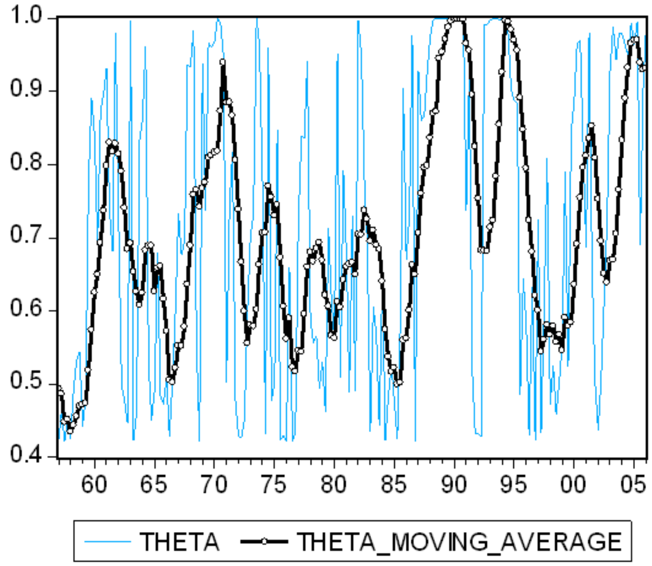

Figure 5: Transition Function 1955Q1-2006Q1

of its sustainability. We observe that that this probability is declining rapidly since the early 1970s, when the UK fiscal deficit had entered a period of non-sustainable fiscal dynamics as discussed in section 5 above. By contrast, the second half of the 1980s saw a significant increase in the value of θ_t , suggesting increasing confidence in the sustainability of the improved fiscal outlook achieved by the UK authorities initiated over that decade. Expectations of being in the inner regime record another marked reduction during the recession of the early 1990s, recovering however within a short period of time coinciding with the high growth rates the UK economy registered following its exit from the Exchange Rate Mechanism in 1992. Finally, we observe another sharp decline in the value of θ_t in the late 1990s. Most likely, however, this is not the result of a substantial deterioration of the UK fiscal outlook but a substantial improvement, leading to expectations that the surpluses the UK economy had been recording over those years (see Figure 1) would not last for long. Indeed, and as Figure 1 suggests, in the subsequent decade of the 2000s public expenditure increased much faster than revenue expectations, eliminating the temporary surpluses achieved in the late 1990s pushing back the deficit within its "normal" range and, as Figure 5 suggests, increasing the probability that the latter will stay there.

7 Conclusion

In this paper we have tested for fiscal policy sustainability in the UK over the period 1955-2006. Using quarterly data and a unified framework of analysis we have addressed four interrelated questions. First, we tested for fiscal policy sustainability accounting for exogenous shifts in UK fiscal policy, which we identify using tests for endogenous structural breaks. Second, we assessed the nature of fiscal policy (Ricardian versus non-Ricardian) in each of the fiscal regimes identified by our structural stability analysis. Third, we tested whether deviations from fiscal sustainability are corrected through adjustments in government revenue or expenditure. Finally, we have tested for non-linearities in UK fiscal policy.

Our main findings can be summarized as follows: First, UK fiscal policy has been sustainable over the period under examination 1955-2006. Second, it has been subject to three structural breaks, respectively located in the early 1970s, early 1980s and late 1990s. These coincide with important shifts in UK fiscal policy, with the first break moving government finances away from sustainability and the remaining two towards it. Third, fiscal policy was sustainable during all sub-periods identified by our analysis, with the exception of 1973-1981 when the UK fiscal regime was non-Ricardian. Fourth, correction of deviations from fiscal sustainability has been taking place through adjustment of public revenue rather than expenditure. Finally, we find evidence of non-linearities in UK fiscal policy, with the UK government not reacting to relatively small deficit values; but correcting exceedingly large deficits relatively fast. Our findings also imply fast correction of exceedingly small deficits or temporary surpluses, which we interpret as evidence that UK authorities use unusually favourable fiscal conditions as a cushion allowing a fast increase in spending and/or reduction in taxation.

Overall, the evidence presented in this paper suggests that UK public finances and the reputation of UK authorities as a fiscally sound borrower were relatively well placed to cope with the fiscal downturn initiated by the global credit crunch of 2007-2008. The intensity of the crisis, however, and the significant ensuing increase in UK public debt have left UK authorities with no room for complacency. There is, of course, ample room for a debate on how fast and in which particular way fiscal adjustment will be best achieved. Nevertheless, there is little doubt that to maintain sustainable government finances, UK fiscal policy would have to be prudent in coming years. In this effort, the credibility of a sound sovereign borrower the UK has accumulated in previous years, as suggested by our analysis, will be a significant advantage.

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