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Modelling the Fiscal Reaction Functions of the GIPS based on State-Varying Thresholds

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Abstract

We extend previous literature on fiscal policy sustainability by introducing non-linear fiscal reaction functions with endogenously estimated state-varying thresholds to capture the behaviour of fiscal policy authorities during "good" and "bad" times. These thresholds vary with the level of debt, the economic cycle and an index of financial pressure.

Keywords: Debt sustainability, fiscal reaction function, state-varying threshold.
JEL Classification: C2, H3, H5

1. Introduction

We estimate non-linear fiscal reaction functions (FRF) for four Eurozone countries (Greece, Ireland, Portugal and Spain; the GIPS), by introducing adjustment thresholds conditional not only on the size of debt but also on the state of the economy and a measure of financial pressure, thereby providing a more accurate description of the behaviour of fiscal policy authorities. Common features of the GIPS include bail-outs from the ECB, the IMF and the European Commission. This justifies the recent concerns and offers a useful ground for sustainability testing. [1]

2. The GIPS' Fiscal Reaction Function

The model-based FRF approach to fiscal sustainability testing requires the estimation of:

[1] Greece, which was bailed-out twice (for €110bn in 2010 and then again for €109bn in 2011) negotiated, in February 2012, a new €130bn rescue package involving a voluntary haircut of some 53.5% on the face value of its bonds held by the private sector. Eurozone ministers agreed (in November 2012) to cut Greece's debt by a further €40bn. Ireland was bailed-out for €85bn in November 2010. Portugal was bailed-out for €78bn in May 2011. Spain was granted, in July 2012, financial assistance from the European Stability Mechanism for up to €100bn.

$$PRIMSURPL_t = a_0 + \rho DEBT_t + \varepsilon_t \quad (1)$$

where $PRIMSURPL_t$ is the ratio of primary surplus to GDP and $DEBT_t$ is the ratio of debt to GDP. A sufficient condition for sustainability is $\rho>0$, implying that governments undertake corrective actions to counteract changes in debt (see, e.g. Bohn, 1998).

A linear FRF such as (1), nevertheless, implicitly assumes that corrective action is invariant with the size of debt, whilst theoretical political economy models suggest a non-linear adjustment, due to the difficulties in reaching the necessary consensus to fiscal consolidation (see, e.g. Bertola and Drazen, 1993). Most recent literature considers some non-linearities in the FRF; Mendoza and Ostry (2008) estimate a cubic FRF for a panel of 56 countries, showing that higher debt countries (in terms of the mean/median of the panel) fail the sustainability test. A similar result is obtained by Theofilakou and Stournaras (2012), for a panel of EU countries exceeding the 60% Maastricht debt criterion. Such literature is nevertheless based on an exogenously created ad-hoc state-invariant threshold, which is arguably unrealistic given the current Eurozone crisis.

We relax the assumption of a continuous and state-invariant fiscal adjustment by estimating the following non-linear FRF:

$$\begin{aligned}\Delta PRIMSURPL_t = {} & \beta_0 + \left(\beta_{11} CV_{t-1} + \beta_{12} cycle_t\right)\theta^s_{t-1} + \left(\beta_{21} CV_{t-1} + \beta_{22} cycle_t\right)(1-\theta^s_{t-1}) + \\ & + \beta_3 \Delta DEBT_{t-1} + \beta_4\, finpressure_t + u_t \end{aligned} \quad (2)$$

where CV_{t-1} are the residuals from the long-run relationship between $PRIMSURPL_t$ and $DEBT_t$, $cycle_t$ is a measure of the economic cycle, u_t is a stochastic error term, $u_t \sim i.i.d.\left(0, \sigma_u^2\right)$ and

$$\theta^s_{t-1} = 1 - [1 + \exp(-\gamma^s (s_{t-1} - \tau^s)/\sigma_{s_{t-1}})]^{-1} \quad (3)$$

is the logistic transition function (see e.g. van Dijk et al, 2002). According to (2)-(3), fiscal policy exhibits regime-switching behavior which depends on whether s_{t-1} (the transition variable) is below or above an endogenously estimated threshold, τ^s with regime weights θ^s_{t-1} and $(1-\theta^s_{t-1})$, respectively [2]. The parameter $\gamma^s > 0$ determines the smoothness of the transition regimes. We make γ^s dimension-free by dividing it by the standard deviation of s_{t-1} (Granger and Teräsvirta, 1993). We consider $DEBT_{t-1}$ and $cycle_{t-1}$ as possible transition variables. $Cycle_t$

[2] In preliminary analysis, we allowed for the intercept term, $\Delta DEBT_{t-1}$ and the *finpressure* variable (discussed below) to vary between regimes but failed to find such evidence.

is proxied by real GDP growth and by the output gap (i.e. output relative to a Hodrick-Prescott trend). Further, we introduce a state-varying threshold of the form:

$$\tau_t^{DEBT} = \tau_0^{DEBT} + \tau_1^{DEBT}\, finpressure_t, \qquad (4)$$

where τ_0^{DEBT} is a fixed threshold and $\tau_1^{DEBT} > 0$ (< 0) implies that during periods of financial pressure, policymakers raise (lower) the debt ceiling above which corrective action is taken; *finpressure* is a composite measure of financial turmoil/crisis and draws heavily on Reinhart and Rogoff (2009)[3].

3. Empirical estimation of the GIPS' non-linear FRF: the main results

We use the longest annual data series from the *AMECO* and IMF databases, and all variables are plotted in Figures 1-2. Preliminary analysis using different unit root tests suggests that *PRIMSURPL* and *DEBT* are both *I*(1) for all countries, consequently we estimate (1) using Johansen's (1995) methodology. *PRIMSURPL* and *DEBT* are cointegrated with a small positive ρ, pointing to the sustainability of the GIPS fiscal policies. [4]

Short-run adjustments are reported in Tables 1-4. All GIPS adjust budgetary disequilibria only in the higher debt regime, and the debt threshold for adjustment is estimated at 69% for Greece, 49% for Ireland, 47% for Portugal and 43% for Spain.

With respect to the state-varying component, for all GIPS the τ_1^{DEBT} estimates are negative and statistically significant, suggesting that, during a period of financial pressure, all GIPS lower the debt threshold, possibly in response to financial market concerns.

We also find a statistically significant growth threshold close to 3% for all GIPS, whilst the output gap resulted statistically insignificant (results on request), signalling that GIPS fiscal authorities might be more concerned with output growth rather than output relative to potential (see e.g. Fatas and Mihov (2008)). For all GIPS, both the cycle impact and fiscal adjustment become stronger when the economy is slowing down (the cycle impact is insignificant for

[3] The index takes into account banking, currency, stock market, debt, and inflation incidences in the world. It pools together world's 20 largest economies with country specific weights given by their relative GDP share of the total GDP (based on Purchasing Power Parity). As alternative measures of financial market pressure, we used the (i) spread between the 10-year yield on the GIPS and the 10-year yield on German bonds, and (ii) a 2(and 3)-year moving standard deviation of the spread but failed to find any significant effect.

[4] We find $\rho<0.10$. To save space, unit root and cointegration test results are not reported but are available on request.

Greece). This suggests some degree of fiscal imprudence from the GIPS's end; instead of prioritising fiscally responsible actions during good times, their corrective action is stronger when growth weakens. For all countries, model (2)-(4) with the state-varying threshold provides the best fit (in terms of a lower regression standard error).

4. Conclusions

We have introduced non-linear FRF with state-varying thresholds to describe the behaviour of the GIPS fiscal policy authorities. Whilst linear models would support the sustainability of the GIPS fiscal policy, our approach documents some relevant shortcomings, justifying current market concerns. Greece fiscal position within this model stands out as its threshold is higher than the 60% reference value of the Maastricht Treaty, its fiscal adjustment is much slower and the primary surplus does not respond to the economic cycle. Further, under pressure from financial markets, all countries lower the debt ceiling above which corrective action is taken. Hence, pressure by financial markets appears to be more effective than the formal excessive deficit procedure (EDP) in making member states correct fiscal imbalances.

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Table 1: **GREECE**-OLS estimates of alternative models for $\Delta PRIMSURPL_t$, 1960-2012

	(i) Linear model	(ii) Logistic model (2)-(3) in text with $s_{t-1}=DEBT_{t-1}$	(iii) Logistic model (2)-(4) in text with $s_{t-1}=DEBT_{t-1}$ and state-varying threshold	(iv) Logistic model (2)-(3) in text with $s_{t-1}=cycle_{t-1}$
Intercept	-1.052 (-1.13)	-1.102 (-1.16)	-1.095 (-1.15)	-1.517 (-1.56)
CV_{t-1}	-0.270 (-2.68)			
$finpressure_t$	-0.063 (-0.07)	0.071 (0.08)	0.064 (0.07)	0.395 (0.64)
$cycle_t$	0.090 (1.093)			
		$\boldsymbol{DEBT_{t-1}} < \tau^{DEBT}$	$\boldsymbol{DEBT_{t-1}} < \tau_t^{DEBT}$	$\boldsymbol{cycle_{t-1}} < \tau^{cycle}$
CV_{t-1}		-0.196 (-1.42)	-0.195 (-1.40)	-0.348 (-3.21)
$cycle_t$		0.102 (1.19)	0.102 (1.18)	0.156 (1.41)
		$\boldsymbol{DEBT_{t-1}} > \tau^{DEBT}$	$\boldsymbol{DEBT_{t-1}} > \tau_t^{DEBT}$	$\boldsymbol{cycle_{t-1}} > \tau^{cycle}$
CV_{t-1}		-0.280 (-2.54)	-0.280 (-2.54)	-0.070 (-0.48)
$cycle_t$		0.050 (0.37)	0.050 (0.37)	0.110 (1.11)
τ^{DEBT}		69.1 (4.32)		
γ^{DEBT}		50.2 (-)*	54.1 (-)*	
τ^{cycle}				2.701 (2.94)
γ^{cycle}				29.2 (-)*
τ_0^{DEBT}			68.0 (3.92)	
τ_1^{DEBT}			-3.80 (-2.21)	
Regression s.e.	1.89	1.87	1.83	1.87
Adjusted R^2	0.13	0.14	0.20	0.14
F*ar* (*p*-value)	0.84	0.86	0.85	0.83
F*arch* (*p*-value)	0.32	0.34	0.35	0.33

Notes: *t*-ratios in parentheses. * Imposed value. van Dijk et al. (2002) argue that the likelihood function is very insensitive to γ, suggesting that precise estimation of this parameter is unlikely. For this reason, we run a grid search in the range [0.1, 250] and fix the γ parameter to the one that delivers the best fit of the estimated models. F*ar* is the Lagrange Multiplier F-test for 2nd order serial correlation. F*arch* is the 1st order ARCH F-test.

Table 2: **IRELAND**-OLS estimates of alternative models for $\Delta PRIMSURPL_t$, 1970-2012

	(i) Linear model	(ii) Logistic model (2)-(3) in text with $s_{t-1}=DEBT_{t-1}$	(iii) Logistic model (2)-(4) in text with $s_{t-1}=DEBT_{t-1}$ and state-varying threshold	(iv) Logistic model (2)-(3) in text with $s_{t-1}=cycle_{t-1}$
Intercept	-2.777 (-1.66)	-3.136 (-1.81)	-3.333 (-1.89)	-2.532 (-1.52)
CV_{t-1}	-0.421 (-4.43)			
$finpressure_t$	0.173 (0.11)	0.116 (0.06)	0.183 (0.10)	-0.214 (-0.13)
$cycle_t$	0.582 (3.11)			
		$\boldsymbol{DEBT_{t-1}} < \tau^{DEBT}$	$\boldsymbol{DEBT_{t-1}} < \tau_t^{DEBT}$	$\boldsymbol{cycle_{t-1}} < \tau^{cycle}$
CV_{t-1}		-0.210 (-0.72)	-0.170 (-0.52)	-0.450 (-3.90)
$cycle_t$		0.585 (1.80)	0.587 (1.58)	0.787 (2.50)
		$\boldsymbol{DEBT_{t-1}} > \tau^{DEBT}$	$\boldsymbol{DEBT_{t-1}} > \tau_t^{DEBT}$	$\boldsymbol{cycle_{t-1}} > \tau^{cycle}$
CV_{t-1}		-0.484 (-4.31)	-0.491 (-4.36)	-0.250 (-1.22)
$cycle_t$		0.603 (2.90)	0.628 (3.77)	0.474 (2.27)
τ^{DEBT}		49.0 (4.24)		
γ^{DEBT}		19.3 (-)*	20.3 (-)*	
τ^{cycle}				2.987 (2.56)
γ^{cycle}				9.2 (-)*
τ_0^{DEBT}			48.0 (3.93)	
τ_1^{DEBT}			-4.01 (-2.33)	
Regression s.e.	3.74	3.72	3.69	3.71
Adjusted R^2	0.35	0.37	0.38	0.37
F*ar* (*p*-value)	0.12	0.14	0.18	0.19
F*arch* (*p*-value)	0.33	0.34	0.34	0.35

Notes: See the notes of Table 1.

Table 3: **PORTUGAL-**OLS estimates of alternative models for $\Delta PRIMSURPL_t$, 1960-2012

	(i) Linear model	(ii) Logistic model (2)-(3) in text with $s_{t-1}=DEBT_{t-1}$	(iii) Logistic model (2)-(4) in text with $s_{t-1}=DEBT_{t-1}$ and state-varying threshold	(iv) Logistic model (2)-(3) in text with $s_{t-1}=cycle_{t-1}$
Intercept	-1.016 (-1.45)	-1.128 (-1.64)	-1.129 (-1.64)	-1.080 (-1.50)
CV_{t-1}	-0.305 (-2.42)			
$finpressure_t$	0.027 (0.04)	-0.434 (-0.54)	-0.450 (-0.56)	-0.147 (-0.21)
$\Delta DEBT_{t-1}$	0.126 (1.35)	0.170 (1.64)	0.170 (1.65)	0.082 (0.85)
$cycle_t$	0.212 (2.19)			
		$\boldsymbol{DEBT_{t-1}} < \tau^{DEBT}$	$\boldsymbol{DEBT_{t-1}} < \tau_t^{DEBT}$	$\boldsymbol{cycle_{t-1}} < \tau^{cycle}$
CV_{t-1}		-0.142 (-0.94)	-0.140 (-0.92)	-0.493 (-2.80)
$cycle_t$		0.185 (1.97)	0.185 (1.97)	0.551 (2.75)
		$\boldsymbol{DEBT_{t-1}} > \tau^{DEBT}$	$\boldsymbol{DEBT_{t-1}} > \tau_t^{DEBT}$	$\boldsymbol{cycle_{t-1}} > \tau^{cycle}$
CV_{t-1}		-0.470 (-2.75)	-0.464 (-2.76)	-0.114 (-0.73)
$cycle_t$		0.470 (2.83)	0.471 (2.83)	0.161 (1.69)
τ^{DEBT}		47.0 (3.24)		
γ^{DEBT}		24.0 (-)*	25.1 (-)*	
τ^{cycle}				2.999 (2.87)
γ^{cycle}				47.1(-)*
τ_0^{DEBT}			45.2 (2.99)	
τ_1^{DEBT}			-3.20 (-2.34)	
Regression s.e.	1.81	1.70	1.68	1.71
Adjusted R^2	0.25	0.32	0.33	0.32
F*ar* (*p*-value)	0.19	0.20	0.20	0.20
F*arch* (*p*-value)	0.78	0.77	0.77	0.78

Notes: See the notes of Table 1.

Table 4: **SPAIN**-OLS estimates of alternative models for $\Delta PRIMSURPL_t$, 1970-2012

	(i) Linear model	(ii) Logistic model (2)-(3) in text with $s_{t-1}=DEBT_{t-1}$	(iii) Logistic model (2)-(4) in text with $s_{t-1}=DEBT_{t-1}$ and state-varying threshold	(iv) Logistic model (2)-(3) in text with $s_{t-1}=cycle_{t-1}$
Intercept	-0.423 (-0.69)	-0.549 (-0.89)	-0.395 (-0.66)	-0.590 (-0.91)
CV_{t-1}	-0.284 (-2.27)			
$finpressure_t$	-1.180 (-2.01)	-1.177 (-2.00)	-1.372 (-2.33)	-1.153 (-1.88)
$\Delta DEBT_{t-1}$	0.087 (1.10)	0.070 (0.83)	0.072 (0.89)	0.064 (0.71)
$cycle_t$	0.438 (4.06)			
		$\boldsymbol{DEBT_{t-1}} < \tau^{DEBT}$	$\boldsymbol{DEBT_{t-1}} < \tau_t^{DEBT}$	$\boldsymbol{cycle_{t-1}} < \tau^{cycle}$
CV_{t-1}		-0.245 (-1.48)	-0.178 (-1.04)	-0.340 (-2.37)
$cycle_t$		0.384 (3.41)	0.334 (2.83)	0.584 (3.08)
		$\boldsymbol{DEBT_{t-1}} > \tau^{DEBT}$	$\boldsymbol{DEBT_{t-1}} > \tau_t^{DEBT}$	$\boldsymbol{cycle_{t-1}} > \tau^{cycle}$
CV_{t-1}		-0.371 (-2.54)	-0.365 (-2.64)	-0.193 (-0.87)
$cycle_t$		0.616 (3.95)	0.596 (4.43)	0.410 (3.64)
τ^{DEBT}		43.0 (3.24)		
γ^{DEBT}		29.4 (-)*	25.7 (-)*	
τ^{cycle}				3.101 (2.87)
γ^{cycle}				44.1 (-)*
τ_0^{DEBT}			44.1 (2.98)	
τ_1^{DEBT}			-2.50 (-2.34)	
Regression s.e.	1.35	1.32	1.30	1.34
Adjusted R^2	0.49	0.53	0.54	0.51
F*ar* (*p*-value)	0.86	0.85	0.83	0.84
F*arch* (*p*-value)	0.11	0.20	0.22	0.23

Notes: See the notes of Table 1.

Figure 1. Primary surplus and debt (% OF GDP) for the GIPS

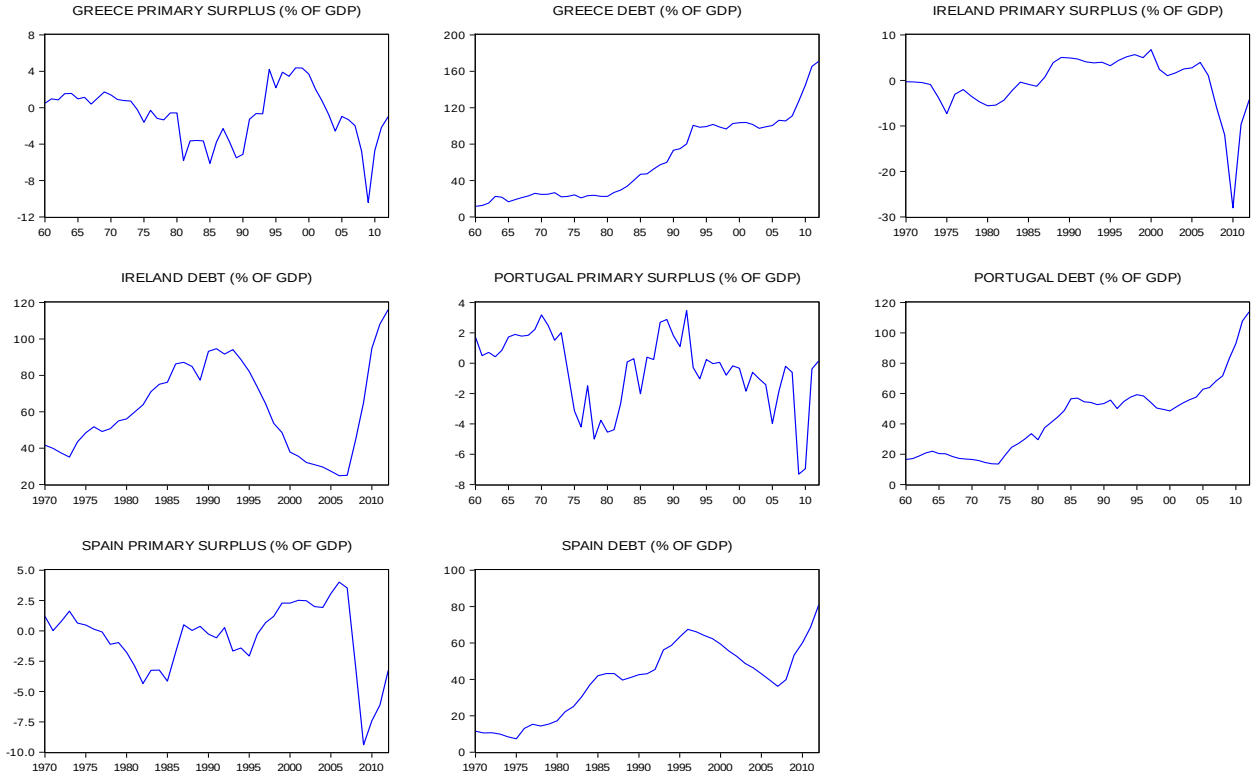

Figure 2. Output growth and financial pressure variable