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Non-Linear Budgetary Policies: Evidence from 150 Years of Italian Public Finance*

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Abstract

We investigate the sustainability of Italy’s public finances from 1862 to 2012 adopting a non-linear perspective. Specifically, we employ the smooth transition regression approach to explore the scope for non-linear fiscal adjustments of primary surpluses in response to the accumulation of debt. The empirical results show the occurrence of a significantly positive reaction of primary surpluses to debt when the debt-GDP ratio exceeded the trigger value of 110 percent. The after-threshold positive response implies that the path of Italy’s fiscal policy is sufficiently consistent with the intertemporal budget constraint.

JEL Classification: E62; H60; C20.

Keywords: Fiscal Policy; Fiscal Sustainability; Non-Linearity.

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1 Introduction

We analyze Italy's budget data over 150 years, from 1862 to 2012. We adopt a non-linear perspective. We employ the smooth transition regression approach (Teräsvirta, 1994, 1998, 2004; Teräsvirta, Tjøstheim and Granger, 2010) to investigate whether a corrective fiscal policy stance significantly emerged as the debt-GDP ratio embarked on potentially unsustainable trajectories. We find robust evidence of a positive feedback reaction of primary surpluses to increases in government debt when the debt-GDP ratio exceeded the value of 110 percent. This value is distant from the 60 percent Maastricht requirement. The existence of a "trigger point", however, ensures that the historical path of Italy's fiscal policy is sufficiently consistent with the government intertemporal budget constraint (Bohn, 1995, 1998).

Our analysis is related to an extensive theoretical and empirical literature on non-linear fiscal adjustments. There are many theoretical reasons for stabilization postponement. In particular, according to Alesina and Drazen (1991) and Bertola and Drazen (1993), political polarization, conflicting distributional objectives among different socioeconomic groups in relation to the burden of fiscal retrenchment, and political stalemate over distribution may prevent from applying timely budgetary adjustments, up to a certain trigger point at which a new consolidated fiscal action may take place to avoid the widespread costs of a debt crisis. Various empirical works indeed show that governments tend to adopt a sufficiently corrective fiscal discipline only when the stance of public finances becomes excessively imbalanced. For the U.S., see Sarno (2001), Arestis, Cipollini and Fattouh (2004), and Cipollini, Fattouh and Mouratidis (2009). For Latin America, see Chortareas, Kapetanios and Uctum (2008). For the U.K., see Conside and Gallagher (2008), and Arghyrou and Fan (2011). For Spain, see Bajo-Rubio, Diaz-Roldan and Esteve (2004, 2006) and Legrenzi and Milas (2012a). For Greece, Ireland, the Netherlands and Portugal, see Arghyrou and Luintel (2007), and Legrenzi and Milas (2012a).

For Italy, Arghyrou and Luintel (2007) find evidence of non-linear fiscal

adjustments of revenues to expenditures from 1957 to 1998; Ricciuti (2008) finds that taxes and spending display non-linear trend stationarity from 1862 to 1998, and further they non-linearly co-trend; Legrenzi and Milas (2012b) show the occurrence of sustainable non-linear tax increases with no evidence for spending corrections from 1960 to 2008; Legrenzi and Milas (2012a) examine the stochastic properties of the debt-GDP ratio series and detect non-linear mean reversion from 1861 to 2010.

This paper makes use of the Italy’s overall historical fiscal record to assess the empirical performance of feedback budgetary policies, that allow for possible tax-smoothing objectives (Barro, 1979, 1986), and explicitly react to debt (Bohn 1998, 2008) in a non-linear way. Our purpose is to infer directly the extent of delayed fiscal adjustments in primary surpluses since the 1861 Italy’s political unification, when debts of all the pre-existent States were incorporated at national level. The issue of government policy feedback to rises in debt-GDP ratios from a non-linear point of view is largely unexplored. Importantly, our approach relying on the surplus-debt relationship enables us to test the consistency of Italy’s historical fiscal policy stance with the intertemporal government budget constraint according to Bohn (1995, 1998).

The paper is organized as follows. Section 2 specifies the model. Section 3 specifies the data. Section 4 presents the empirical results. Section 5 summarizes the main conclusions.

2 Model Specification

As pointed out in the Introduction, the primary objective of the paper is to investigate the scope for non-linear adjustments of primary surpluses in reaction to debt accumulation over the fiscal history of Italy. For this purpose, our empirical investigation is based on a smooth transition regression (STR) model of the form

$$s_t = \phi' \mathbf{z}_t + \theta' \mathbf{z}_t G(\gamma, c, b_{t-1}) + u_t, \quad (1)$$

$$G(\gamma, c, b_{t-1}) = \left(1 + \exp \left\{ - (\gamma / \hat{\sigma}_b^K) \prod_{k=1}^K (b_{t-1} - c_k) \right\} \right)^{-1}, \quad (2)$$

where s_t is the primary surplus-GDP ratio in period t , $t = 1, \dots, T$, $\mathbf{z}_t = (\mathbf{w}'_t, \mathbf{x}'_t)'$ is a vector of explanatory variables, given by $\mathbf{w}_t = (1, s_{t-1}, \dots, s_{t-p})'$ and $\mathbf{x}_t = (b_{t-1}, \tilde{g}_t, \dots, \tilde{g}_{t-q}, \tilde{y}_t, \dots, \tilde{y}_{t-r})'$, which contains additional determinants of s_t , specifically the previous period's debt-GDP ratio b_{t-1} , and measures of temporary government spending \tilde{g}_t and temporary output \tilde{y}_t ; $\phi = (\phi_0, \phi_1, \dots, \phi_m)'$ and $\theta = (\theta_0, \theta_1, \dots, \theta_m)'$ are vectors of regression coefficients; $u_t \sim \text{iid}(0, \sigma^2)$; $G(\gamma, c, b_{t-1})$ is a logistic transition function, bounded between 0 and 1, which depends on the transition variable b_{t-1} , the “slope” parameter $\gamma > 0$ standardized by the K th power of the sample standard deviation of b_{t-1} , $\hat{\sigma}_b^K$, and a vector of “threshold” parameters $c = (c_1, \dots, c_K)'$, with $c_1 \leq \dots \leq c_K$.

The fiscal policy reaction function expressed by (1) and (2) encompasses three main features. It exhibits a non-linear primary surplus-debt relationship, in order to verify whether increases in the debt-GDP ratio triggered, possibly above a “threshold” point, endogenous upward shifts in primary surpluses, that are sufficient for sustainability according to Bohn (1998). It controls for temporary spending, due for instance to periods of wars, and temporary output, due for instance to periods of recession, in order to incorporate the possibility of tax smoothing in fiscal policy making according to Barro (1979, 1986). It takes into account potential inertia, a typical feature of policy reaction functions.

Consistently with Teräsvirta (1994, 1998, 2004), testing linearity against the STR model requires the use of the following auxiliary regression, obtained by a third-order Taylor approximation of the transition function (2) in (1) around the null hypothesis of linearity given by $\gamma = 0$:

$$s_t = \beta'_0 \mathbf{z}_t + \sum_{j=1}^3 \beta'_j \tilde{\mathbf{z}}_j b_{t-1}^j + u_t^*, \quad (3)$$

where $\mathbf{z}_t = (1, \tilde{\mathbf{z}}_t)'$, and u_t^* is function of u_t . From (3), the null hypothesis of linearity is

$$H_{01} : \beta_1 = \beta_2 = \beta_3 = 0. \quad (4)$$

Under H_{01} , the test statistic has an approximate F -distribution with $3m$ and $T - 4m - 1$ degrees of freedom. In the case of rejection of H_{01} , regression (3) can be used to select the value of K in (2) by performing the test sequence given by

$$H_{04} : \beta_3 = 0, \quad (5)$$

$$H_{03} : \beta_2 = 0 | \beta_3 = 0, \quad (6)$$

$$H_{02} : \beta_1 = 0 | \beta_2 = \beta_3 = 0. \quad (7)$$

Rejection of H_{04} leads to $K = 1$ with a non-zero threshold; rejection of H_{03} leads to $K = 2$; rejection of H_{02} leads to $K = 1$ with a zero threshold.

3 Data

Italian historical annual data for central government budget and GDP in nominal terms are collected from Fratianni and Spinelli (2001) for the period 1861-1998 and from the *Annual Report* of the Bank of Italy for the period 1999-2012. Data for real GDP are from Maddison. The primary surplus series s_t is computed by dividing the difference of nominal revenues and nominal outlays net of interest payments on debt by nominal GDP. The debt-GDP ratio series b_t results by dividing the end-of-period nominal debt by nominal GDP. Temporary spending \tilde{g}_t and temporary output \tilde{y}_t are obtained by detrending the outlay-GDP ratio and the real GDP growth rate, using the HP filter as in Mendoza and Ostry (2008).

4 Empirical Results

Table 1 shows linearity tests against the STR specification (1)-(2) with $p = 2$ and $q = r = 1$, lags yielding a parsimonious non-linear model satisfying all

misspecification tests emphasized by Teräsvirta (2004). The hypothesis of non-linearity in fiscal policy clearly outperforms the hypothesis of linearity.¹ In particular, rejection of H_{01} and H_{03} favors the STR model with $K = 2$.

The model is estimated by conditional maximum likelihood using the iterative BFGS quasi-Newton algorithm (Hendry, 1995; Teräsvirta, 2004). Remarkably, the model is linear in the parameters when (γ, c_1, c_2) are fixed in the transition function. Therefore, a grid search is performed to pin down the starting values for the estimation that minimize the residuals sum of squared. The obtained starting values are $\gamma = 40.112$, $c_1 = 0.300$, and $c_2 = 1.083$.

Table 2 shows regression results. In the estimated equation, there is neither error autocorrelation nor heteroskedasticity. There is no remaining non-linearity. Feedback parameters do not display smooth continuous change, in favor of our specification.

In the linear part of the estimated policy function, the regression coefficient on the outstanding debt-GDP ratio b_{t-1} insignificantly differs from zero at 5 percent level, and is even significantly negative at 10 percent level (-0.015 , with t-statistic = -1.833).² In the non-linear part, in contrast, the coefficient becomes positive and highly significant (0.047 , with t-statistic = 3.893).³ The upward corrections in primary surpluses are triggered above a high-debt threshold c_2 approximately equal to 110 percent (1.099 , with t-statistic = 185.365).⁴ Consequently, our finding of a non-linear but event-

¹For a conventional analysis based on unit root tests and fiscal feedback rules under the linearity framework, see Piergallini and Postigliola (2012).

²Temporary spending \tilde{g}_t enters negatively (-0.910 , with t-statistic = -13.560), consistently with tax smoothing theory. Countercyclical fiscal actions are further detected, as temporary output \tilde{y}_{t-1} enters positively (0.051 , with t-statistic = 1.726).

³In this alternative fiscal regime, the degree of tax smoothing due to temporary spending \tilde{g}_t is dampened by 0.438 (with t-statistic = 2.314). This appears in line with the increased policy concern over debt stabilization.

⁴The large estimated value of γ (119.754) implies a sharp transition between fiscal regimes. The lack of many observations in the neighborhood of c_1 and c_2 results in a large standard deviation. As pointed out by Teräsvirta (2004), however, because of this lack of information and the fact that the STR model is identified only under the alternative, not the null, hypothesis of linearity, the implied t-statistic (0.315) is not a test of the hypothesis $\gamma = 0$. See also Bates and Watts (1988), Seber and Wild (1989) on the issue.

ally positive surplus-debt relationship implies the occurrence of fiscal actions by Italian governments excessively postponed over time, consistently with the theoretical predictions elaborated by Bertola and Drazen (1993), but sufficiently precluding Ponzi's games, consistently with the fiscal requirements for sustainability in a stochastic environment elaborated by Bohn (1995, 1998). Indeed, according to Bohn (1995, 1998), the critical requirement for the intertemporal budget constraint to be satisfied prescribes that government policy should respond to the debt-accumulation process by increasing the primary surplus at least linearly for high debt-GDP ratios. In our case, the estimated coefficients on the outstanding debt b_{t-1} and autoregressive components of s_t yield a long-run reaction of the primary surplus-GDP ratio in the high-debt regime of $0.047/[1 - (1.369 - 0.815) - (-0.347 + 0.416)] \approx 0.125$. Hence, an increase in the debt-GDP ratio, say, by 10 percentage points starting from the 110 percent debt threshold gives rise to a permanent increase in the primary surplus-GDP ratio by about 1.25 percentage points. This after-threshold policy reaction restores long-term sustainability of Italian public finances.

5 Conclusions

Delayed corrective budgetary policies, ruling out globally unsustainable debt paths, are shown to capture consistently the behavior of Italian fiscal authorities over 150 years following the 1861 political unification. The empirical analysis presented in this paper, based on the smooth transition regression framework, indicates that Italian governments historically performed persistent increases in the primary surplus-GDP ratio once the debt-GDP ratio passed above a threshold level of 110 percent. This “trigger point” is far from the 60 percent Maastricht reference value, but the implied fiscal action, featuring a permanent upward adjustment of the primary surplus-GDP ratio by 1.25 percentage points in response to an increase in the debt-GDP ratio by 10 percentage points in the regime beyond the threshold, satisfies the intertemporal budget constraint.

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Tables

TABLE 1
Linearity Tests against STR, 1862-2012

Hypothesis	Transition variable: b_{t-1}
H_{01}	0.003
H_{04}	0.300
H_{03}	2.2782×10^{-4}
H_{02}	0.453

Notes: p-Values of F-tests (4)-(7).

TABLE 2
Non-Linear Regression Results, 1862-2012

Dependent variable: s_t	start	estimate	t-statistic
<i>- linear part -</i>			
constant	0.015	0.015	1.931
s_{t-1}	1.365	1.369	20.611
s_{t-2}	-0.345	-0.347	-6.044
b_{t-1}	-0.015	-0.015	-1.833
\tilde{g}_t	-0.914	-0.910	-13.560
\tilde{g}_{t-1}	1.111	1.112	13.113
\tilde{y}_t	-0.006	-0.006	-0.210
\tilde{y}_{t-1}	0.051	0.051	1.726
<hr/>			
<i>- non-linear part -</i>			
<i>(transition variable: b_{t-1})</i>			
constant	-0.047	-0.045	-4.021
s_{t-1}	-0.835	-0.815	-5.488
s_{t-2}	0.422	0.416	3.302
b_{t-1}	0.050	0.047	3.893
\tilde{g}_t	0.433	0.438	2.314
\tilde{g}_{t-1}	-0.786	-0.763	-3.975
\tilde{y}_t	0.135	0.142	1.500
\tilde{y}_{t-1}	0.133	0.134	1.455
γ	40.112	119.754	0.315
c_1	0.300	0.303	85.871
c_2	1.083	1.099	185.365
<hr/>			
$\overline{R}^2 = 0.97$			
Serial correlation	AR(1)=[0.740], AR(2)=[0.599]		
Heteroskedasticity	ARCH(1)=[0.779], ARCH(2)=[0.381]		
Remaining non-linearity	H_{01} =[0.346], H_{04} =[0.287], H_{03} =[0.361], H_{02} =[0.468]		
Parameter constancy	H_1 =[0.070], H_2 =[0.201], H_3 =[0.185]		
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Notes: Estimates of the STR model (1)-(2) with annual data; estimates are obtained using the iterative BFGS quasi-Newton algorithm (Hendry, 1995; Teräsvirta, 2004); the lags $p = 2$ and $q = r = 1$ are selected to obtain a parsimonious non-linear model consistent with misspecification tests (Teräsvirta, 2004); \bar{R}^2 = adjusted coefficient of determination; $AR(i)$ = Lagrange-multiplier (LM) test for serial correlation in the residuals (Godfrey, 1988; Teräsvirta, 2004) up to order i ; $ARCH(i)$ = LM test for autoregressive conditional heteroskedasticity (ARCH) in the residuals (Engle, 1982) up to order i ; LM-type tests of remaining non-linearity use the auxiliary regression $s_t = \beta'_0 \mathbf{z}_t + \theta' \mathbf{z}_t G(\gamma, c, b_{t-1}) + \sum_{j=1}^3 \beta'_j \tilde{\mathbf{z}}_j b_{t-1}^j + u_t^*$ (Teräsvirta, 2004) and verify the hypotheses $H_{01} : \beta_1 = \beta_2 = \beta_3 = 0$, $H_{04} : \beta_3 = 0$, $H_{03} : \beta_2 = 0 | \beta_3 = 0$, $H_{02} : \beta_1 = 0 | \beta_2 = \beta_3 = 0$; LM-type tests of parameter constancy of the STR model (1)-(2) are against smooth continuous change in feedback parameters according to a time-varying STR model (TV-STR) (Lundbergh, Teräsvirta and van Dijk, 2003) of the form $s_t = \phi(t)' \mathbf{z}_t + \theta(t)' \mathbf{z}_t G(\gamma, c, b_{t-1}) + u_t$, where $\phi(t) = \phi + \lambda_\phi H_\phi(\gamma_\phi, c_\phi, t^*)$ and $\theta(t) = \theta + \lambda_\theta H_\theta(\gamma_\theta, c_\theta, t^*)$, where $t^* = t/T$, $H_\phi(\gamma_\phi, c_\phi, t^*)$ and $H_\theta(\gamma_\theta, c_\theta, t^*)$ are of the form (2) with $b_{t-1} = t^*$, for $K = 1$ (H_1), $K = 2$ (H_2), and $K = 3$ (H_3); the TV-STR model is reparameterized by performing Taylor expansions around the null hypothesis of parameter constancy given by $\gamma_\phi = \gamma_\theta = 0$ (Teräsvirta, 2004); [] = p-values of F-tests.