# Non-linear budgetary policies: Evidence from 150 years of Italian public finance☆

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## HIGHLIGHTS

- We explore Italy's fiscal sustainability for 1862–2012 from a non-linear perspective.
- We infer the extent of delayed fiscal adjustments to debt accumulation.
- Primary surpluses react to debt above a debt–GDP threshold ratio of 110%.
- The non-linear surplus–debt relation sufficiently precludes Ponzi's games.
- Results are consistent with political-economy models on postponed fiscal actions.

## ARTICLE INFO

## 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.

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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 et al., 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%. This value is distant from the 60% 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 US, see Sarno (2001), Arestis et al. (2004) and Cipollini et al. (2009). For Latin America, see Chortareas et al. (2008). For the UK, see Considine

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and Gallagher (2008) and Arghyrou and Fan (2011). For Spain, see Bajo-Rubio et al. (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

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

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

where $s_t$ is the primary surplus–GDP ratio in period $t$, $t = 1, \ldots, T$, $\mathbf{z}_t = (\mathbf{w}_t', \mathbf{x}_t')'$ is a vector of explanatory variables, given by $\mathbf{w}_t = (1, s_{t-1}, \ldots, s_{t-p})'$ and $\mathbf{x}_t = (b_{t-1}, \tilde{g}_t, \ldots, \tilde{g}_{t-q}, \tilde{y}_t, \ldots, \tilde{y}_{t-r})'$, 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 $\tilde{y}_t$; $\phi = (\phi_0, \phi_1, \ldots, \phi_m)'$ and $\theta = (\theta_0, \theta_1, \ldots, \theta_m)'$ are vectors of regression coefficients; $u_t \sim$ i.i.d. $(0, \sigma^2)$; $G(\gamma, c, b_{t-1})$ 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 $c = (c_1, \ldots, c_K)'$, with $c_1 \leq \cdots \leq c_K$.

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.

**Table 1**
Linearity tests against STR, 1862–2012.

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

*Notes*: $p$-values of $F$-tests (4)–(7).

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 $\gamma = 0$:

$$s_t = \beta_0' \mathbf{z}_t + \sum_{j=1}^{3} \beta_j' \widetilde{\mathbf{z}}_t b_{t-1}^j + u_t^*, \tag{3}$$

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

$$H_{01}: \beta_1 = \beta_2 = \beta_3 = 0. \tag{4}$$

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

$$H_{04}: \beta_3 = 0, \tag{5}$$

$$H_{03}: \beta_2 = 0 | \beta_3 = 0, \tag{6}$$

$$H_{02}: \beta_1 = 0 | \beta_2 = \beta_3 = 0. \tag{7}$$

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 $(\gamma, c_1, c_2)$ are fixed in the transition function. Therefore, a grid search is performed to pin down the starting values

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