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Abstract

We examine the historical dynamics of government debt in Post-Unification Italy, from 1861 to 2009. Unit root tests for the debt-GDP ratio are unable to reject either the non-stationarity or the stationarity null hypothesis. Controlling debt dynamics for fiscal feedback policies of the Barro-Bohn style, however, the debt-GDP ratio is found to be mean-reverting. Mean-reversion in the debt-GDP ratio is due not only to a nominal growth dividend, but also to a positive response of primary surpluses to variations in outstanding debt. There is indeed significant evidence that, over the history of Italy, fiscal policy makers have reacted to the accumulation of debt, taking corrective measures to rule out potential long-term sustainability problems.

JEL Classification: E62; H60; C20.

Keywords: Fiscal Policy; Public Debt; Fiscal Sustainability.

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"Now I believe that one really imposes burdens on taxpayers not when one votes taxes, but when one votes expenditures".

Quintino Sella, *Finance Minister* (*Italian House of Representatives, December 11, 1872*).

1 Introduction

The Italy's nominal public debt is the third largest in the world after the United States and Japan.[1] The Italy's public debt-GDP ratio is the eleventh largest in the world after Liberia, Japan, St. Kitts and Nevis, Guinea-Bissau, Lebanon, the Democratic Republic of Congo, Jamaica, Seychelles, Grenada, and Antigua and Barbuda.[2]

Debt and deficits in Italy have sharply increased following the Great Recession started in 2007. The sustainability of the Italian fiscal policy has thus turned to be a critical issue. In current public policy debates, it is often argued that the 2009-2010 debt crisis occurred in Greece and Ireland could generate contagion and moral hazard problems in other Euro Area Member States, notably Portugal, Spain, and Italy.

Did Italy's fiscal policy makers react to debt accumulation in the past? Is Italy's public debt on a sustainable path? In this paper we examine the historical dynamics of government debt in Post-Unification Italy, from 1861 to 2009.

In 1861, the first Finance Minister of the Kingdom of Italy, Pietro Bastogi, set up the "Gran Libro del Debito Pubblico Italiano" to incorporate the debts of all the existent states before the Unification. Thereafter, with the exception of the first three years of the new Kingdom (from 1861 to 1863), of one year over the Fascist period (1926), and of the first thirty-six years over the post-World War II period (from 1946 to 1981), the time series of the Italian debt-GDP ratio has well been above 0.6, the threshold value established in the Maastricht Treaty; see Figure 1.

Stationarity in the debt-GDP ratio, as emphasized by Bohn (2007), appears to be the most relevant econometric condition to check whether fiscal policy is sustainable or may

[1] See International Monetary Fund (2010).
[2] See Abbas, Belhocine, ElGanainy, and Horton (2010).

generate potential solvency problems.[3] It is in fact empirically implausible, as emphasized by Chung, Davig and Leeper (2007), that the debt-GDP ratio can grow without limit and, at the same time, be perceived by economic agents as sustainable.

Table 1 displays unit root tests for the Italy's debt-GDP ratio in the Post-Unification period. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests examine the null hypothesis of a unit root against the alternative hypothesis of stationarity.[4] The Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test examines the null hypothesis of stationarity against the alternative hypothesis of a unit root.[5]

The results over the whole period are puzzling. The ADF and PP tests are in favor of the non-stationarity null hypothesis for the debt-GDP ratio.[6] The KPSS is instead in favor of the stationarity null hypothesis. The conflicting results also hold over remarkable sub-periods. For example, in Table 1 they are shown to hold over the whole sample excluding world war-time periods (from 1914 to 1919, and from 1939 to 1947), up to the World War I (from 1861 to 1913), and up to the World War II (from 1861 to 1938).[7]

Therefore, the ADF and PP tests seem to suggest absence of corrective measures by Italy's fiscal policy makers, and hence potential debt sustainability problems, for economic agents are likely to perceive the non-stationary debt dynamics as unrelated to fundamentals. The KPSS test, by contrast, seems to suggest no potential sustainability problems at all.

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[3] Specifically, Bohn (2007) demonstrates that deriving sustainability tests from the government's intertemporal budget constraint imposes very weak econometric restrictions for testing the sustainability hypothesis. This is essentially because the intertemporal budget constraint is fully satisfied by government policies that let the debt-GDP ratio increase exponentially at a rate just marginally below the discount rate. The government's intertemporal budget constraint hence turns out to be satisfied even if the debt-GDP ratio is stationary after any finite number of differencing operations.

[4] See Hamilton (1994).

[5] See Kwiatkowski, Phillips, Schmidt, and Shin (1992).

[6] This finding continues to apply taking into account the possibility of structural breaks. The Clemente-Montañés-Reyes unit root test (see Clemente, Montañés, and Reyes, 1998) using the "additive outlier" model (CLEMAO) with one endogenous structural break gives a t-value of -2.599, greater than the critical 5 percent value of -3.560, signaling the optimal breakpoint in 1917. The CLEMAO test with two endogenous structural breaks gives a t-value of -4.980, greater than the critical 5 percent value of -5.490, signaling the optimal breakpoints in 1948 and 1986.

[7] ADF, PP and KPSS tests give however unambiguous results, in favor of the non-stationarity hypothesis, over the sample up to the 1991 global recession and the Maastricht Treaty (from 1861 to 1990), even excluding world war-time periods, and over the post-World War II sample (from 1948 to 2009). Galli and Padovano (2008) also find evidence of non-stationarity over the period from 1950 to 2002.

However, unit root tests arguably do not control for the behavior of governments' primary surpluses, as first shown by Bohn (1998) for the U.S. fiscal history. Then we incorporate the main determinants of primary-surplus policies, based on tax-smoothing theory (Barro, 1979, 1986), into the government's budget constraint. This yields a dynamic equation in the debt-GDP ratio that can be estimated in order to detect stability or instability. We find significant evidence of mean-reversion in the debt-GDP ratio. The result is robust over several sub-periods. We show how mean-reversion in the debt-GDP ratio comes not only from a *nominal* growth dividend, but also from a positive response of primary surpluses to variations in outstanding debt. We indeed find significant evidence that, over the history of Italy, fiscal policy makers have reacted to the accumulation of debt, taking corrective actions to rule out potential sustainability problems.

The scheme of the paper is as follows. Section 2 investigates the relationship between debt and primary surpluses and derives the implications for the dynamics of Italy's government debt. Section 3 extends the analysis by incorporating inertia in the fiscal policy adjustment process in response to increases in debt. Section 4 summarizes the main conclusions.

2 Fiscal Feedback Policies and Debt Dynamics

In the Introduction we have pointed out that unit root tests for the Italy's debt-GDP ratio yield conflicting results. Neither the null hypothesis of a unit root, in the case of ADF and PP tests, nor the null hypothesis of stationarity, in the case of the KPSS test, can significantly be rejected. Unit root tests, however, arguably abstract from economic theory. Specifically, they do not control for the determinants of primary surpluses, as first shown by Bohn (1998) for the U.S. fiscal history.

To illustrate this point in a transparent way, consider first the government's budget identity, $B_t = (1 + i_t) B_{t-1} + G_t - T_t$, describing how the nominal public debt B_t at the end of period t depends on the nominal interest rate i_t, the previous period's nominal public debt B_{t-1}, the non-interest public spending G_t, and total revenues T_t. Define the government's primary surplus as $S_t = T_t - G_t$. Then divide both sides of the budget identity by the nominal GDP Y_t to get the law of motion of the debt-GDP ratio,

$$b_t = (1 + r)\, b_{t-1} - s_t, \tag{1}$$

where $b_t = B_t/Y_t$, $s_t = S_t/Y_t$, and $r = (1 + i_t) / (1 + n_t)$ is the nominal interest rate deflated by the nominal growth rate, $n_t = (Y_t - Y_{t-1}) / Y_{t-1}$. The assumption of a fixed after-growth interest rate r is common in the literature, and here is adopted only to make the argument as transparent as possible, without loss of generality. Suppose now that the primary surplus-GDP ratio is an increasing function of the outstanding debt-GDP ratio. Specifically, consider a policy function of the form

$$s_t = \rho b_{t-1} + \boldsymbol{\alpha} \mathbf{Z}_t + \varepsilon_t, \tag{2}$$

where $\rho > 0$ captures the degree of reactiveness of the primary surplus to debt, $\mathbf{Z}_t$ is a vector of additional determinants of the primary surplus, $\boldsymbol{\alpha}$ is a vector of parameters, and ε_t is a mean-zero error term. Substituting (2) into (1) results in the following equation describing the dynamics of the debt-GDP ratio:

$$\Delta b_t = (r - \rho)\, b_{t-1} + \boldsymbol{\beta} \mathbf{Z}_t + v_t. \tag{3}$$

where $\boldsymbol{\beta} = -\boldsymbol{\alpha}$ and $v_t = -\varepsilon_t$. Assume that $\mathbf{Z}_t$ is stationary. Then the debt-GDP ratio is mean-reverting if $r - \rho < 0$. According to (3), standard unit root tests can easily fail to detect mean-reversion in the debt-GDP ratio for two reasons. First, if $r - \rho$ is strictly below zero - but not much below zero - unit root tests can easily lead to accept the unit root null hypothesis. Second, unit root tests are misspecified since they omit $\mathbf{Z}_t$, that is, the non-debt determinants of the primary surplus.

Standard tax-smoothing theory (Barro, 1979, 1986) suggests that $\mathbf{Z}_t$ should incorporate the level of temporary government spending and the level of temporary output. When government spending is temporarily high, for example because of wars, and/or the level of output is temporarily low, for example because of recessions, sudden increases in tax rates necessary to maintain a balanced budget would bring about unnecessary economic distortions, affecting agents' choices for optimal time paths of labor, production, consumption, and investment. Therefore, it is optimal for the government to let the debt-GDP ratio increase in periods of temporarily high levels of spending and/or in periods of temporarily low levels of output.

This implies an empirical specification for the change in the debt-GDP ratio of the form

$$\Delta b_t = \gamma b_{t-1} + \beta_0 + \beta_1 \tilde{g}_t + \beta_2 \tilde{y}_t + v_t, \tag{4}$$

where $\tilde{g}_t$ is a measure of temporary government spending, $\tilde{y}_t$ is a measure of temporary output, and $(\gamma, \beta_0, \beta_1, \beta_2)$ are regression coefficients. Following Mendoza and Ostry (2008), we obtain $\tilde{g}_t$ and $\tilde{y}_t$ by detrending real government spending and real GDP, using the Hodrick-Prescott filter with the smoothing parameter equal to 100. The resulting "government spending gap" $\tilde{g}_t$ and the "output gap" $\tilde{y}_t$ are shown in Figures 2-3.

For $\tilde{g}_t$, the major peaks are associated with war-time periods: 0.34 during the Third Italian War of Independence in 1866, 0.12 at the beginning of the African War in Eritrea in 1888, 0.55 at the end of the World War I in 1918, 0.44 during the World War II in 1941; peaks are also visible after the Great Depression (0.10 in 1936), at the beginning of the Italian "economic miracle", the so-called "Golden Age", (0.10 in 1953), during the 1970s stagflation period (0.16 in 1978), after the 11 September 2001 terrorist attacks (0.16 in 2001), and during the current Great Recession (0.09 in 2009).

For $\tilde{y}_t$, the major peaks are again associated with war-time periods: 0.09 during the African War in 1891, 0.13 at the end of the World War I in 1918, 0.18 at the beginning of the World War I in 1939, -0.44 at the end of the World War II; peaks are also visible after the breakdown of trade relations between Italy and France (-0.11 in 1889), at the beginning of the Golden Age (0.05 in 1951), and during the current Great Recession (-0.05 in 2009).

Table 2 shows estimates of equation (4). All estimates use Ordinary Least Squares (OLS). Both ordinary and robust t-statistics are displayed, to take into account heterosckedasticity and autocorrelation in residuals. Robust t-statistics are computed using the Newey-West (Newey and West, 1987) heteroskedasticity and autocorrelation consistent covariance matrix. Regression 1 shows the results for the whole sample period from 1861 to 2009. Regression 2 excludes the World War I period (from 1914 to 1919) and the World War II period (from 1939 to 1947). Regression 3 shows the results up to the World War I (from 1861 to 1913). Regression 4 shows the results up to the World War II (from 1861 to 1938). Regression 5 shows the results up to the Maastricht period (from 1861 to 1990), excluding world war-time periods in Regression 6. Regression 7 shows the results for the post-World War II period (from 1948 to 2009).

For Regression 1 in Table 2, the γ coefficient on the lagged debt-GDP ratio b_{t-1} is significantly negative (-0.036, with robust t-statistic = -2.087), in favor of mean-reversion in the debt-GDP ratio. The β_1 coefficient on the temporary spending $\tilde{g}_t$ is significantly positive (0.198, with robust t-statistic = 3.439), consistently with tax smoothing. The β_2 coefficient on the temporary output $\tilde{y}_t$ insignificantly differs from zero (0.041, with robust t-statistic = 0.205).

Excluding world war-time periods, the mean-reversion result is more pronounced, and a positive effect of temporary declines in output on debt accumulation is detected, consistently with tax smoothing. From Regression 2 in Table 2, in fact, the coefficient on the lagged debt-GDP ratio is significantly negative (-0.042, with robust t-statistic = -2.229). The coefficient on the temporary spending is again significantly positive (0.208, with robust t-statistic = 3.314). The coefficient on the temporary output is now significantly negative (-0.529, with robust t-statistic = -2.504).

The general result of mean-reversion in the debt-GDP ratio holds over the sub-periods considered in Regressions 3-6 in Table 2.[8]

Let us also use an alternative measure of temporary government spending and temporary output, based on the closed-form solution of Barro's (1986) tax-smoothing framework. The two measures are referred as $GVAR_t$ for government spending and $YVAR_t$ for output,

[8] Regression 7 indicates, instead, a countercyclical fiscal response over the post-World War II with no statistically significant evidence of mean-reversion in the debt-GDP ratio.

and are given by $GVAR_t = \left(g_t - g_t^T\right)/y_t$ and $YVAR_t = \left(g_t^T/y_t\right)\left[\left(y_t^T - y_t\right)/y_t\right]$, where g_t is real government spending, y_t is real output, and g_t^T and y_t^T are corresponding trend values. A positive value of $YVAR_t$ now denotes a period of temporary recession while a negative value denotes a period of temporary expansion. As for $\tilde{g}_t$ and $\tilde{y}_t$, trends are obtained using the Hodrick-Prescott filter with the smoothing parameter equal to 100.[9] The resulting $GVAR_t$ and $YVAR_t$ for Italy are shown in Figures 4-5. The empirical specification for the change in the debt-GDP ratio is now

$$\Delta b_t = \gamma b_{t-1} + \beta_0 + \beta_1 GVAR_t + \beta_2 YVAR_t + v_t, \tag{5}$$

Table 3 shows estimates of equation (5). Mean-reversion in the debt-GDP ratio continues to be detected for Regressions 1-6 in Table 3. For example, for Regression 1, which considers the whole sample 1861-2009, the γ coefficient on b_{t-1} is significantly negative (-0.035, with robust t-statistic $= -2.179$); the β_1 coefficient on $GVAR_t$ is significantly positive (0.819, with robust t-statistic = 3.275), as Barro's (1986) framework predicts; the β_2 coefficient on $YVAR_t$ insignificantly differs from zero (-0.125, with robust t-statistic $= -0.373$), but becomes significantly positive in Regressions 2-4 and 6-7, consistently with tax smoothing.

To see why mean-reversion in the debt-GDP ratio is detected, recall the definition of the coefficient on b_{t-1} in equation (4), $\gamma = r - \rho$, where r is the nominal interest rate on government debt net of the growth rate of the nominal GDP, and ρ is the feedback response of the primary surplus-GDP ratio to increases in the debt-GDP ratio. Let first concentrate on the after-growth interest rate, r. Consistently with Bohn (2008), let calculate the nominal interest rate on debt i_t as the ratio of interest payments for period t over the average of the stock of nominal debt at the end of period t and at the end of period $t-1$.[10] For the whole sample, the average nominal interest rate on debt is 4.9 percent; the

[9] Bohn (2008) measures temporary government spending for the U.S. as the difference between the actual and the estimated permanent military spending-GDP ratio. For the U.S. fiscal history, fluctuations are in fact dominated by military spending. For the Italy's fiscal history, however, fluctuations in government spending are not only dominated by military spending. Therefore, following Mendoza and Ostry (2008), we continue to use a standard measure for $g_t - g_t^T$.

[10] Computing the nominal interest rate in this way enables us to take into account the fact that gov-

average nominal GDP-growth rate is 10.2 percent, more than 3/4 due to inflation and less than 1/4 due to real GDP growth;[11] thus, $r = (1 + 0.049) / (1 + 0.102) - 1 \approx -0.048 < 0$. This implies that the "nominal growth dividend" has exceeded the interest cost on public debt, preventing *per se* the debt-GDP ratio from embarking on unstable paths.

Let now focus on the degree of reaction of primary surpluses to increases in debt, ρ. Figure 6 shows the historical behavior of the primary surplus-GDP ratio. Negative peaks are dominated by the world war-time periods. Positive increases are particularly visible from 1869 to 1876 during the "Historical Right" period, from 1922 to 1927 during the Fascist period, from 1952 to 1957 during the Golden Age, from 1991 to 1997 during the Maastricht period, from 2002 to 2004 during the second Berlusconi's government, and from 2006 to 2008 during the last Prodi's government. Table 4 shows estimates of the policy function

$$s_t = \rho b_{t-1} + \alpha_0 + \alpha_1 \tilde{g}_t + \alpha_2 \tilde{y}_t + \varepsilon_t, \tag{6}$$

where $(\rho, \alpha_0, \alpha_1, \alpha_2)$ are regression coefficients. The ρ coefficient on the outstanding debt-GDP ratio is positive and highly significant in all Regressions. For example, for Regression 1 in Table 4 the ρ-value is 0.076 (with robust t-statistic = 3.032). This means that an increase in the debt-GDP ratio, say, by 10 percentage points has implied an increase in the primary surplus-GDP ratio by 0.76 percentage points on average. The variable $\tilde{g}_t$ enters negatively (−0.309, with robust t-statistic = −3.115) and the variable $\tilde{y}_t$ enters positively (0.447, with robust t-statistic = 1.671), consistently with tax smoothing. A significantly positive value of ρ is also detected substituting the measures $\tilde{g}_t$ and $\tilde{y}_t$ with $GVAR_t$ and $YVAR_t$; see Table 5.

As a consequence, mean-reversion in the debt-GDP ratio is due not only to a nominal growth dividend, but also to a positive response of primary surpluses to variations in the outstanding debt. This positive response is sufficient for long-term sustainability of Italy's fiscal policy.

ernment debt is composed of a portfolio of securities with different interest rates.

[11] Specifically, the average percentage increase in the GDP deflator is 7.7 percent while the average percentage increase in real GDP is 2.5 percent.

3 Incorporating Fiscal Policy Inertia

It is worth generalizing the above analysis to account for a potential inertia in the reaction of the primary surplus to debt accumulation. Specifically, consider a policy function of the form

$$s_t = \delta s_{t-1} + (1-\delta)\,\rho b_{t-1} + \boldsymbol{\alpha}\mathbf{Z}_t + \varepsilon_t, \tag{7}$$

where $0 < \delta < 1$ is a parameter capturing the gradual adjustment of the primary surplus to debt. Combining (7) with (1) now yields

$$\mathbf{x}_t = \mathbf{J}\mathbf{x}_{t-1} + \mathbf{u}_t, \tag{8}$$

where

$$\mathbf{x}_t = \begin{pmatrix} b_t \\ s_t \end{pmatrix}, \qquad \mathbf{u}_t = \begin{pmatrix} -\boldsymbol{\alpha}\mathbf{Z}_t - \varepsilon_t \\ \boldsymbol{\alpha}\mathbf{Z}_t + \varepsilon_t \end{pmatrix},$$

and

$$\mathbf{J} = \begin{pmatrix} (1+r) - (1-\delta)\,\rho & -\delta \\ (1-\delta)\,\rho & \delta \end{pmatrix}. \tag{9}$$

The characteristic polynomial of $\mathbf{J}$ is $\mathrm{P}(\lambda) = \lambda^2 - \mathrm{Tr}\mathbf{J}\lambda + \mathrm{Det}\mathbf{J}$. Stability requires that the two roots lie inside the unit circle. This applies if and only if the following conditions are satisfied:[12]

$$|\mathrm{Det}\mathbf{J}| < 1, \tag{10}$$

$$1 + \mathrm{Tr}\mathbf{J} + \mathrm{Det}\mathbf{J} > 0, \tag{11}$$

$$1 - \mathrm{Tr}\mathbf{J} + \mathrm{Det}\mathbf{J} > 0. \tag{12}$$

From (9), $\mathrm{Tr}\mathbf{J} = (1+r) - (1-\delta)\,\rho + \delta$ and $\mathrm{Det}\mathbf{J} = (1+r)\,\delta$. It follows that conditions (10)-(12) are satisfied if and only if

$$\delta\,(1+r) < 1, \tag{13}$$

[12] See LaSalle (1986).

$$\rho < \frac{(1+r)(1+\delta)}{(1-\delta)}, \tag{14}$$

$$\rho - r > 0. \tag{15}$$

Table 6 shows estimates of the policy function

$$s_t = \delta s_{t-1} + \phi b_{t-1} + \alpha_0 + \alpha_1 \tilde{g}_t + \alpha_2 \tilde{y}_t + \varepsilon_t. \tag{16}$$

Using $GVAR_t$ and $YVAR_t$ instead of $\tilde{g}_t$ and $\tilde{y}_t$ yields estimates reported in Table 7. The ϕ coefficient on the lagged debt-GDP ratio is significantly positive in Regressions 1-4 and 6-7 in Tables 6-7. Over the full sample period 1861-2009, the ϕ-value is approximately equal to 0.015 (0.014 with robust t-statistic = 1.753 for Regression 1 in Table 6, and 0.019 with robust t-statistic = 2.154 for Regression 1 in Table 7). With a δ-value approximately equal to 0.85 (0.860 with robust t-statistic = 18.198 for Regression 1 in Table 6, and 0.825 with robust t-statistic = 16.393 for Regression 1 in Table 7), this implies a ρ-value approximately equal to $0.015/(1-0.85) \approx 0.1$, which is remarkably comparable with the ρ-values displayed in Tables 4-5. This means that an increase in the debt-GDP ratio, for instance, by 10 percentage points generates an increase in the primary surplus-GDP ratio by 1 percentage point in the long run.

Conditions for stability (10)-(12) are verified. Condition (10) is satisfied because δ is lower than unity and Italy's nominal interest rates have been below Italy's nominal GDP-growth rates on average, implying $r < 0$. Condition (11) is satisfied because the values of $\phi = (1-\delta)\rho$ are largely below unity. Finally, condition (12) is satisfied because beyond the occurrence of a nominal growth dividend, ρ is significantly positive.

4 Conclusions

The paper has analyzed Italy's long-term budget data. Unit root tests for the debt-GDP ratio are unable to reject either the null hypothesis of stationarity or the null hypothesis of non-stationarity. Then we have controlled for fiscal feedback policies à la Barro-Bohn, based on tax-smoothing theory. We have found significant evidence of mean-reversion in the debt-GDP ratio. We have shown how mean-reversion reflects not only a *nominal* growth dividend, but also a positive reaction of primary surpluses to increases in debt. The results thus favor the hypothesis of long-term sustainability in Italy's fiscal policy making.

Appendix: Description of the Data

The debt series b_t is obtained by dividing the end-of-period central government nominal debt (Fratianni and Spinelli (2001) from 1861 to 1998; Bank of Italy, *Relazione Annuale*, from 1999 to 2009) by nominal GDP (Obstfeld and Jones (2001) from 1861 to 1889; Rossi, Sorgato, and Toniolo (1993), from 1890 to 1970; Bank of Italy, *Relazione Annuale*, from 1971 to 2009).

The primary surplus series s_t is obtained by dividing the difference of central government nominal revenues (Repaci (1962) from 1862 to 1952; Bank of Italy, *Relazione Annuale*, from 1953 to 2009) and central government nominal outlays (Repaci (1962) from 1862 to 1952; Bank of Italy, *Relazione Annuale*, from 1953 to 2009) net of interest payments on debt (Fratianni e Spinelli (2001) from 1862 to 1998; Bank of Italy, *Relazione Annuale*, from 1999 to 2009) by nominal GDP.

The real government spending series g_t is obtained by dividing central government nominal outlays by the GDP deflator (Fratianni and Spinelli (2001) from 1861 to 1998; ISTAT, *Bollettino Statistico*, from 1999 to 2009).

The real GDP series y_t is obtained by dividing the nominal GDP by the GDP deflator.

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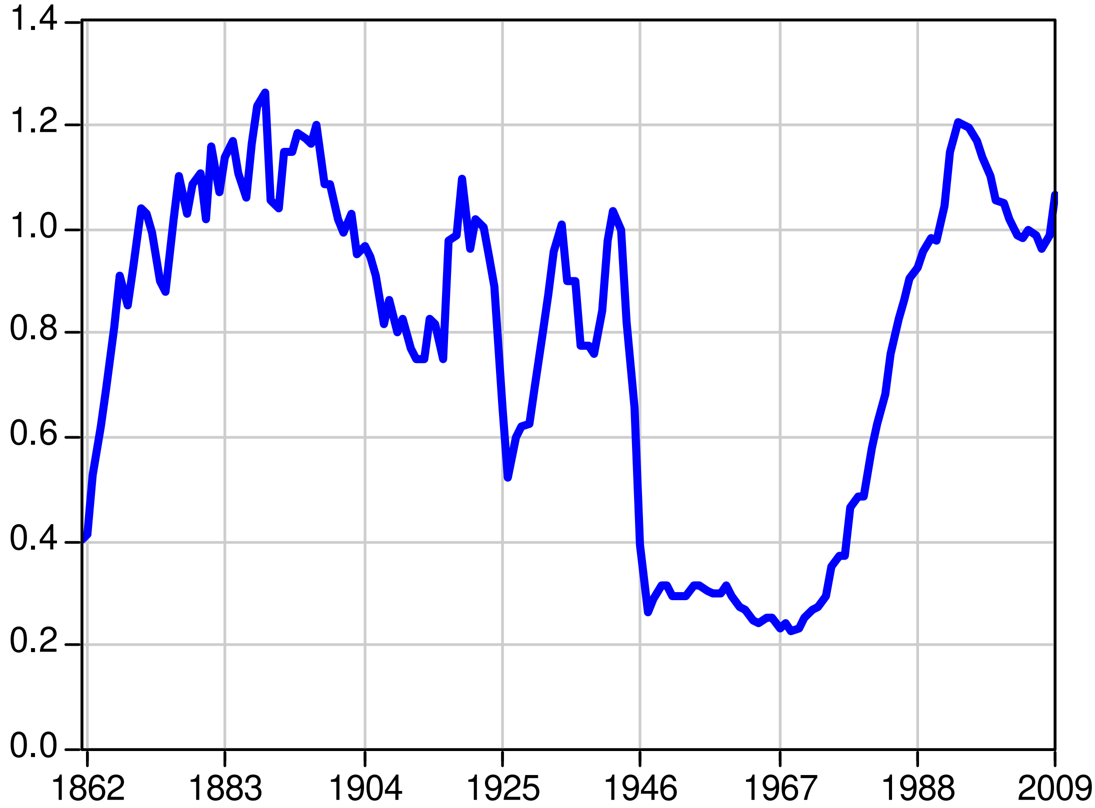

Figure 1: The Italy's government debt-GDP ratio, 1861-2009.

Note: The graph shows the Italy's debt-GDP ratio series b_t described in the Appendix.

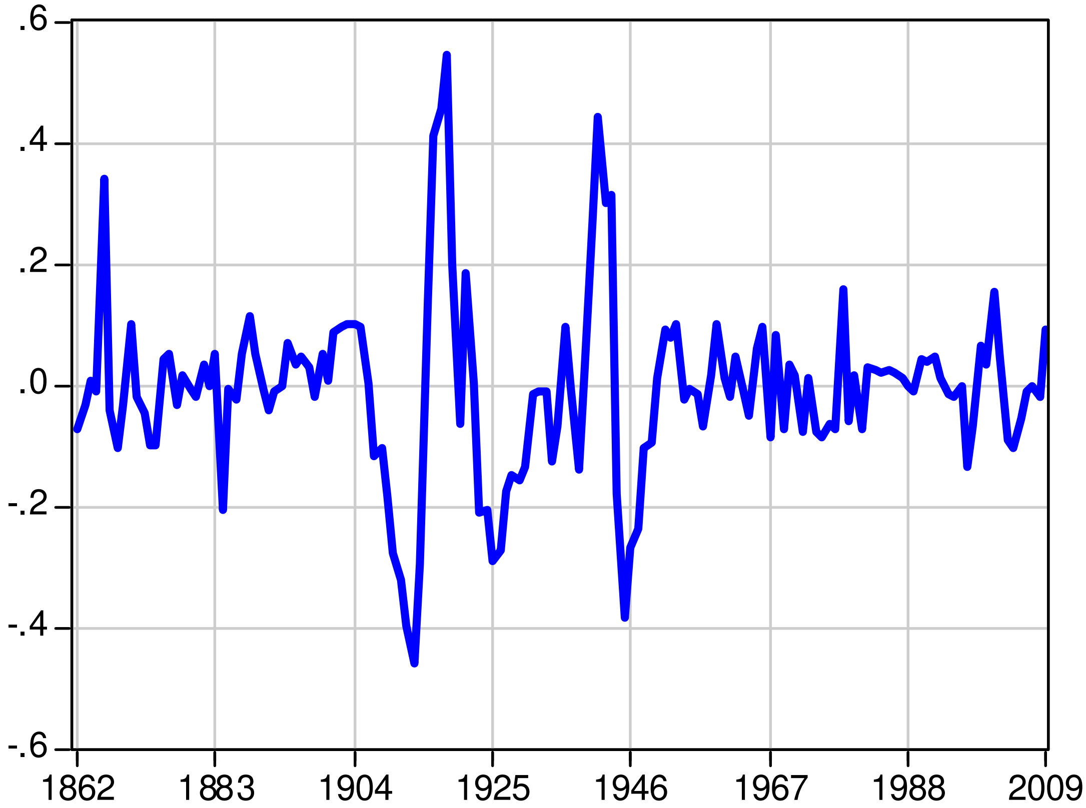

Figure 2: The Italy's temporary government spending $\tilde{g}_t$, 1862-2009.

Note: The graph shows the Italy's temporary government spending, obtained by detrending the real government spending series g_t described in the Appendix, using the Hodrick-Prescott filter with the smoothing parameter equal to 100.

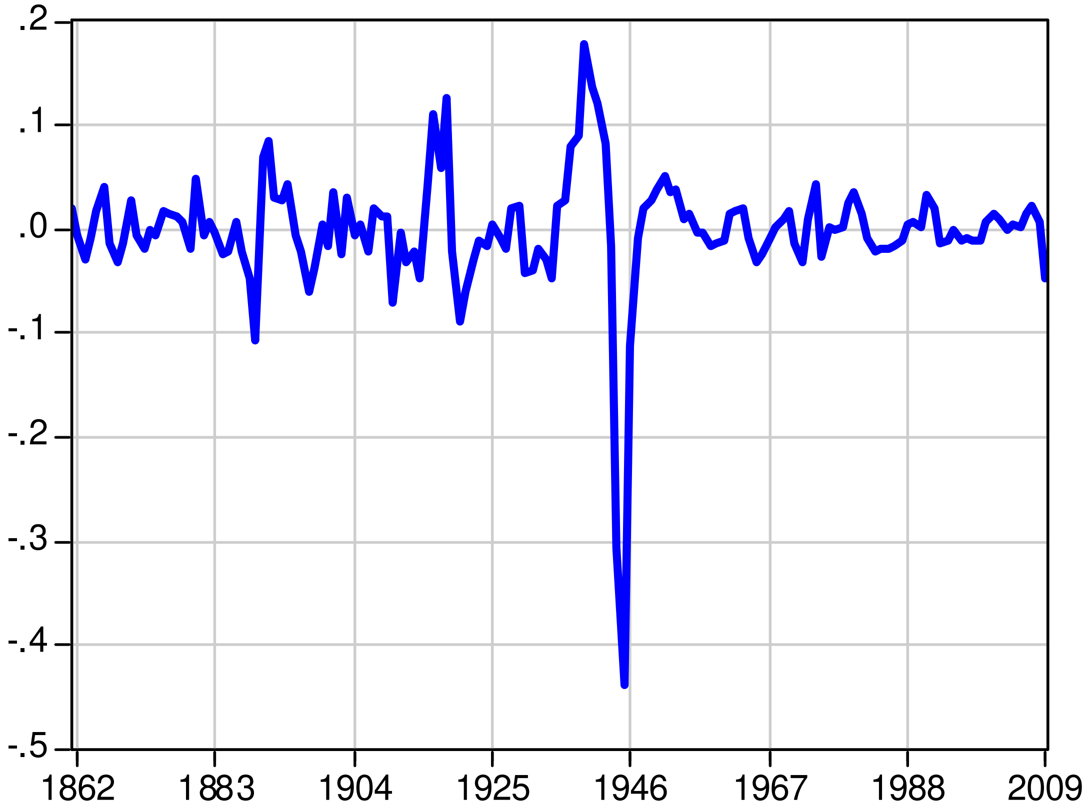

Figure 3: The Italy's temporary output $\tilde{y}_t$, 1861-2009.

Note: The graph shows the Italy's temporary output, obtained by detrending the real GDP series y_t described in the Appendix, using the Hodrick-Prescott filter with the smoothing parameter equal to 100.

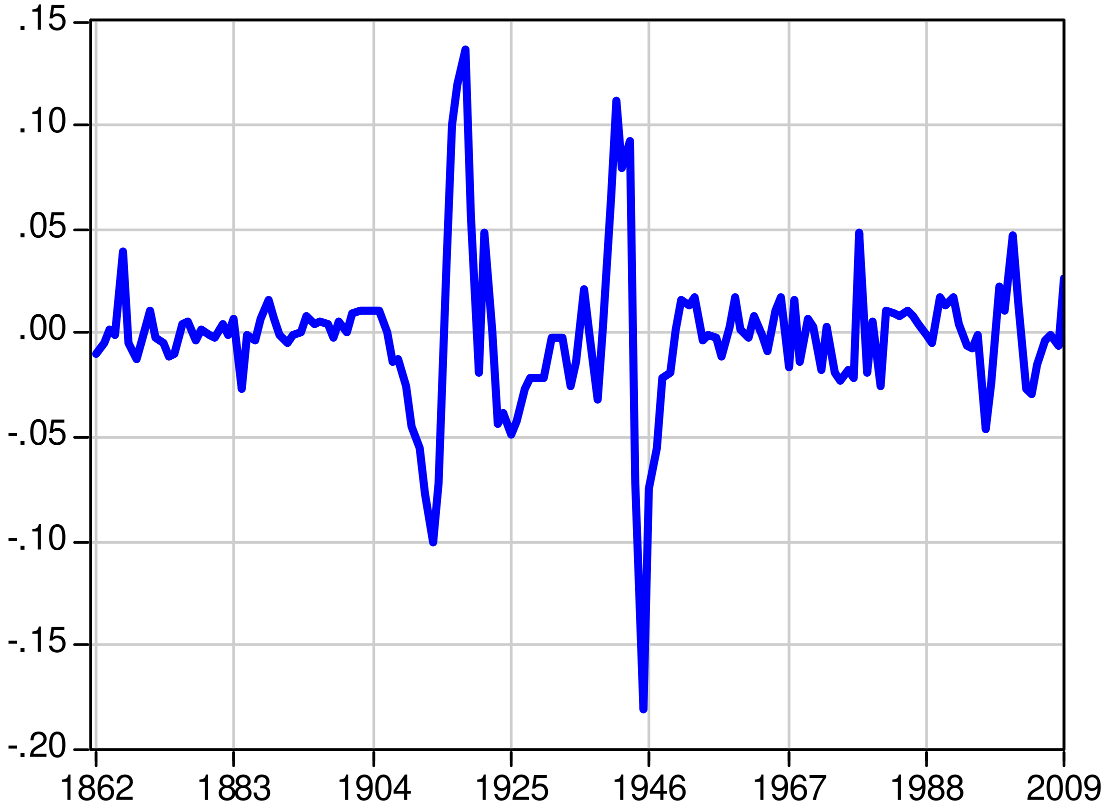

Figure 4: The Italy's temporary government spending $GVAR_t$, 1862-2009.

Notes: The graph shows the Italy's temporary government spending based on Barro's (1986) model, according to which $GVAR_t = \left(g_t - g_t^T\right)/y_t$, where g_t and y_t are the real government spending series and the real GDP series, respectively, described in the Appendix; g_t^T represents the trend of the g_t series; the trend is obtained using the Hodrick-Prescott filter with the smoothing parameter equal to 100.

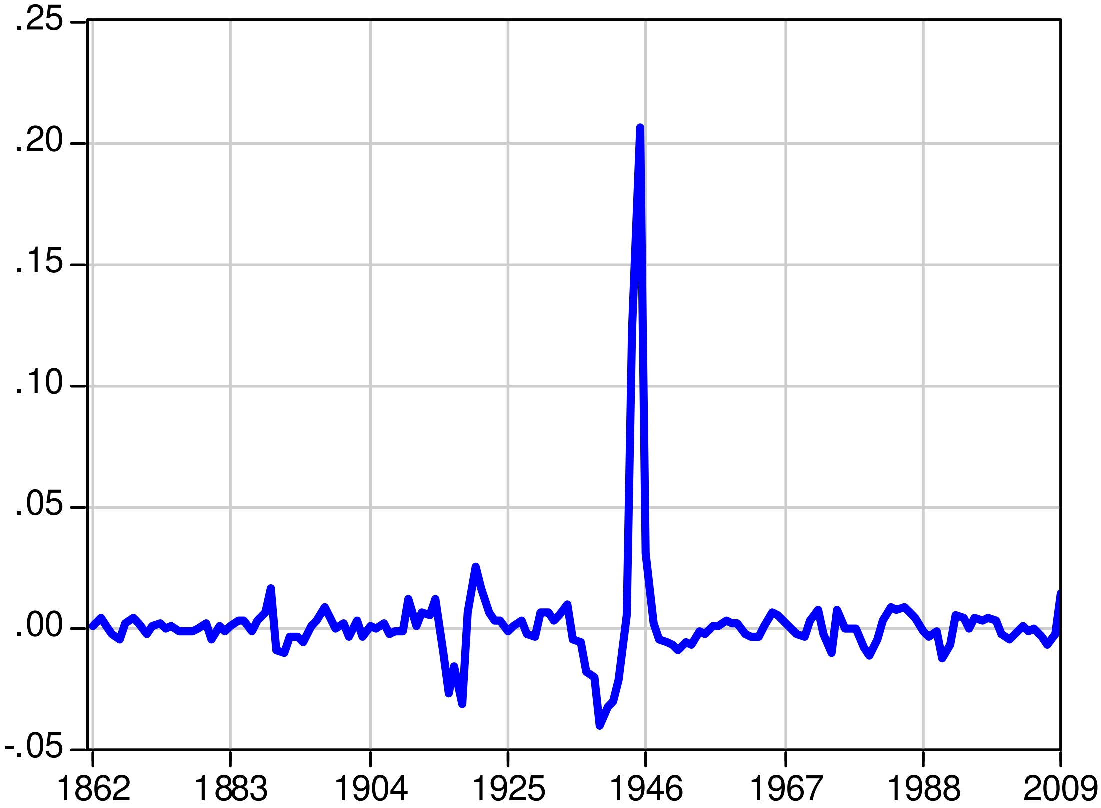

Figure 5: The Italy's temporary output $YVAR_t$, 1861-2009.

Notes: The graph shows the Italy's temporary output based on Barro's (1986) model, according to which $YVAR_t = \left(g_t^T/y_t\right)\left[\left(y_t^T - y_t\right)/y_t\right]$, where y_t is the real GDP series described in the Appendix; y_t^T and g_t^T represent the trends of the real government spending series g_t and the real GDP series y_t described in the Appendix; the trends are obtained using the Hodrick-Prescott filter with the smoothing parameter equal to 100.

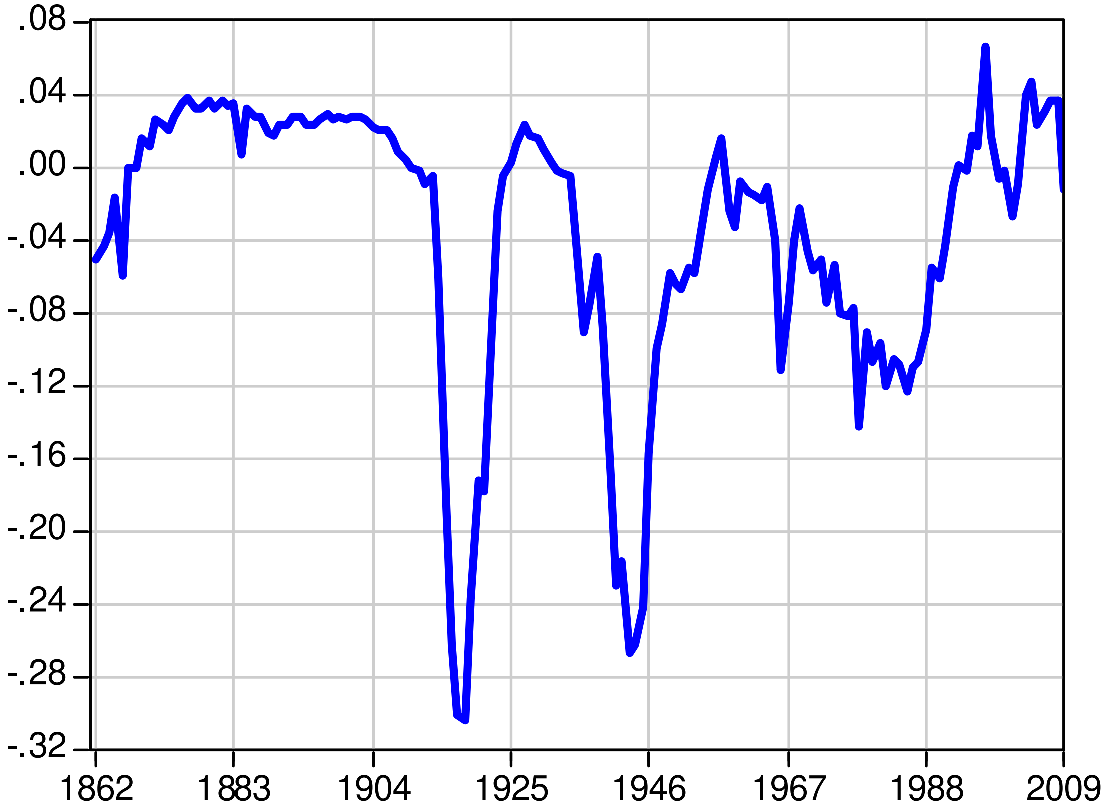

Figure 6: The Italy's primary surplus-GDP ratio, 1862-2009.

Note: The graph shows the Italy's primary surplus-GDP ratio series s_t described in the Appendix.

Table 1: Unit root tests for the debt-GDP ratio.

Sample	ADF	PP	KPSS
(1) 1861-2009	−1.914	−1.884	0.347
	(−3.475)	(−3.475)	(0.739)
	[−2.881]	[−2.881]	[0.463]
(2) 1861-2009	−2.056	−2.141	0.319
excl. 14-19, 39-47	(−3.480)	(−3.480)	(0.739)
	[−2.883]	[−2.883]	[0.463]
(3) 1861-1913	−2.878	−2.883	0.294
	(−3.563)	(−3.563)	(0.739)
	[−2.919]	[−2.919]	[0.463]
(4) 1861-1938	−2.923	−2.967	0.262
	(−3.518)	(−3.518)	(0.739)
	[−2.900]	[−2.900]	[0.463]
(5) 1861-1990	−1.847	−1.792	0.759
	(−3.482)	(−3.482)	(0.739)
	[−2.884]	[−2.884]	[0.463]
(6) 1861-1990	−1.973	−2.029	0.660
excl. 14-19, 39-47	(−3.489)	(−3.489)	(0.739)
	[−2.887]	[−2.887]	[0.463]
(7) 1948-2009	−0.622	−0.406	0.844
	(−3.540)	(−3.540)	(0.739)
	[−2.909]	[−2.909]	[0.463]

Notes: ADF = Augmented Dickey-Fuller test with intercept and lag length selected according to the Schwarz Information Criterion (maximum lags = 4); PP = Phillips-Perron test with intercept and Newey-West bandwidth using Bartlett kernel; KPSS = Kwiatkowski-Phillips-Schmidt-Shin test with intercept and Newey-West bandwidth using Bartlett kernel; ( ) = critical values at 1% significance level; [ ] = critical values at 5% significance level.

Table 2: Regression results for the change in the debt-GDP ratio, using $\tilde{g}_t$ and $\tilde{y}_t$.

Equation for Δb_t						
Sample	Const.	b_{t-1}	$\tilde{g}_t$	$\tilde{y}_t$	R^2	DW
(1) 1861-2009	0.035	−0.036	0.198	0.041	0.188	1.652
	(2.323)	(−2.059)	(4.730)	(0.397)		
	[2.116]	[−2.087]	[3.439]	[0.205]		
(2) 1861-2009	0.043	−0.042	0.208	−0.529	0.195	1.459
excl. 14-19, 39-47	(3.320)	(−2.735)	(4.440)	(−3.119)		
	[2.536]	[−2.229]	[3.314]	[−2.504]		
(3) 1861-1913	0.193	−0.186	0.262	−0.538	0.347	1.870
	(4.193)	(−4.054)	(3.708)	(−1.988)		
	[4.389]	[−4.281]	[4.473]	[−2.225]		
(4) 1861-1938	0.193	−0.196	0.282	−0.772	0.377	1.749
	(4.924)	(−4.782)	(5.457)	(−3.746)		
	[6.139]	[−5.613]	[4.694]	[−3.247]		
(5) 1861-1990	0.036	−0.039	0.199	0.049	0.197	1.706
	(2.241)	(−1.999)	(4.451)	(0.452)		
	[2.162]	[−2.153]	[3.302]	[0.252]		
(6) 1861-1990	0.044	−0.044	0.210	−0.512	0.197	1.524
excl. 14-19, 39-47	(3.131)	(−2.538)	(4.142)	(−2.805)		
	[2.502]	[−2.184]	[3.165]	[−2.323]		
(7) 1948-2009	0.017	−0.004	0.062	−0.512	0.103	0.710
	(2.000)	(−0.336)	(0.948)	(−2.418)		
	[1.393]	[−0.202]	[0.942]	[−2.463]		

Notes: OLS estimates with annual data; ( ) = ordinary t-statistics; [ ] = robust t-statistics, computed using the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix with lag truncation $q = \text{floor}\left(4\left(\mathrm{T}/100\right)^{\frac{2}{9}}\right)$, where T is the number of observations; DW = Durbin-Watson statistic.

Table 3: Regression results for the change in the debt-GDP ratio, using $GVAR_t$ and $YVAR_t$.

Equation for Δb_t						
Sample	Const.	b_{t-1}	$GVAR_t$	$YVAR_t$	R^2	DW
(1) 1861-2009	0.034	−0.035	0.819	−0.125	0.197	1.747
	(2.282)	(−2.033)	(4.393)	(−0.406)		
	[2.244]	[−2.179]	[3.275]	[−0.373]		
(2) 1861-2009	0.042	−0.041	0.912	2.161	0.155	1.535
excl. 14-19, 39-47	(3.104)	(−2.606)	(3.696)	(2.501)		
	[2.551]	[−2.302]	[2.952]	[1.746]		
(3) 1861-1913	0.194	−0.187	1.439	4.013	0.313	1.881
	(4.053)	(−3.931)	(3.293)	(1.943)		
	[4.090]	[−4.010]	[3.664]	[2.323]		
(4) 1861-1938	0.181	−0.186	1.289	3.867	0.326	1.735
	(4.481)	(−4.387)	(4.783)	(3.441)		
	[5.779]	[−5.565]	[3.951]	[2.312]		
(5) 1861-1990	0.035	−0.039	0.842	−0.123	0.207	1.803
	(2.077)	(−1.952)	(4.055)	(−0.765)		
	[2.309]	[−2.261]	[3.086]	[−0.367]		
(6) 1861-1990	0.042	−0.044	0.979	2.076	0.156	1.599
excl. 14-19, 39-47	(2.961)	(−2.448)	(3.473)	(2.136)		
	[2.522]	[−2.292]	[2.720]	[1.489]		
(7) 1948-2009	0.016	−0.004	0.309	2.140	0.136	0.703
	(1.991)	(−0.344)	(1.291)	(2.696)		
	[1.425]	[−0.186]	[0.048]	[2.593]		

Notes: OLS estimates with annual data; ( ) = ordinary t-statistics; [ ] = robust t-statistics, computed using the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix with lag truncation $q = \text{floor}\left(4\left(\text{T}/100\right)^{\frac{2}{9}}\right)$, where T is the number of observations; DW = Durbin-Watson statistic.

Table 4: Regression results for the primary surplus-GDP ratio, using $\tilde{g}_t$ and $\tilde{y}_t$.

Equation for s_t						
Sample	Const.	b_{t-1}	$\tilde{g}_t$	$\tilde{y}_t$	R^2	DW
(1) 1861-2009	−0.099	0.076	−0.309	0.447	0.330	0.194
	(−6.826)	(4.472)	(−7.577)	(4.470)		
	[−4.456]	[3.032]	[−3.115]	[1.671]		
(2) 1861-2009	−0.082	0.079	−0.097	0.211	0.300	0.235
excl. 14-19, 39-47	(−8.438)	(6.985)	(−2.801)	(1.687)		
	[−5.063]	[4.617]	[−2.658]	[0.808]		
(3) 1861-1913	−0.080	0.097	−0.012	0.055	0.705	1.376
	(−8.598)	(10.488)	(−0.871)	(1.009)		
	[−5.058]	[6.468]	[−0.477]	[1.348]		
(4) 1861-1938	−0.146	0.135	−0.267	−0.069	0.385	0.238
	(−4.037)	(3.550)	(−5.586)	(−0.360)		
	[−2.837]	[2.831]	[−2.326]	[−0.229]		
(5) 1861-1990	−0.093	0.064	−0.307	0.442	0.309	0.187
	(−6.014)	(3.327)	(−7.021)	(4.161)		
	[−4.146]	[2.137]	[−3.125]	[1.686]		
(6) 1861-1990	−0.080	0.076	−0.086	0.209	0.263	0.209
excl. 14-19, 39-47	(−7.681)	(5.882)	(−2.269)	(1.541)		
	[−4.921]	[3.906]	[−2.198]	[0.777]		
(7) 1948-2009	−0.077	0.061	−0.201	0.188	0.264	0.189
	(−6.967)	(3.919)	(−2.359)	(0.681)		
	[−4.460]	[2.798]	[−2.847]	[0.589]		

Notes: OLS estimates with annual data; ( ) = ordinary t-statistics; [ ] = robust t-statistics, computed using the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix with lag truncation $q = \text{floor}\left(4\left(T/100\right)^{\frac{2}{9}}\right)$, where T is the number of observations; DW = Durbin-Watson statistic.

Table 5: Regression results for the primary surplus-GDP ratio, using $GVAR_t$ and $YVAR_t$.

Equation for s_t						
Sample	Const.	b_{t-1}	$GVAR_t$	$YVAR_t$	R^2	DW
(1) 1861-2009	−0.099	0.080	−1.583	−2.192	0.443	0.249
	(−7.530)	(5.171)	(−9.532)	(−7.998)		
	[−4.624]	[3.369]	[−3.937]	[−4.361]		
(2) 1861-2009	−0.083	0.081	−0.578	−1.515	0.332	0.216
excl. 14-19, 39-47	(−8.765)	(7.272)	(−3.328)	(−2.490)		
	[−5.037]	[4.662]	[−3.135]	[−0.939]		
(3) 1861-1913	−0.079	0.097	−0.059	−0.458	0.705	1.394
	(−8.444)	(10.355)	(−0.688)	(−1.127)		
	[−4.995]	[6.434]	[−0.464]	[−1.510]		
(4) 1861-1938	−0.140	0.130	−1.506	−0.296	0.479	0.241
	(−4.238)	(3.747)	(−6.829)	(−0.322)		
	[−3.113]	[3.096]	[−2.679]	[−0.145]		
(5) 1861-1990	−0.095	0.071	−1.614	−2.216	0.429	0.240
	(−6.761)	(4.058)	(−8.920)	(−7.564)		
	[−4.323]	[2.518]	[−3.971]	[−4.484		
(6) 1861-1990	−0.082	0.078	−0.508	−1.684	0.294	0.205
excl. 14-19, 39-47	(−7.992)	(6.173)	(−2.534)	(−2.437)		
	[−4.882]	[4.029]	[−2.527]	[−0.937]		
(7) 1948-2009	−0.078	0.062	−0.865	−0.866	0.291	0.186
	(−7.207)	(4.066)	(−2.771)	(−0.836)		
	[−4.613]	[2.953]	[−3.483]	[−0.590]		

Notes: OLS estimates with annual data; ( ) = ordinary t-statistics; [ ] = robust t-statistics, computed using the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix with lag truncation $q = \text{floor}\left(4\left(\text{T}/100\right)^{\frac{2}{9}}\right)$, where T is the number of observations; DW = Durbin-Watson statistic.

Table 6: Regression results for the primary surplus-GDP ratio, using $\tilde{g}_t$ and $\tilde{y}_t$, and in the presence of inertia.

	Equation for s_t						
Sample	Const.	s_{t-1}	b_{t-1}	$\tilde{g}_t$	$\tilde{y}_t$	R^2	DW
(1) 1861-2009	−0.017	0.860	0.014	−0.103	0.034	0.893	1.214
	(−2.587)	(27.279)	(1.988)	(−5.678)	(0.798)		
	[−2.306]	[18.198]	[1.753]	[−3.623]	[0.476]		
(2) 1861-2009	−0.021	0.769	0.023	−0.066	0.083	0.852	1.826
excl. 14-19, 39-47	(−4.044)	(21.787)	(3.865)	(−4.128)	(1.417)		
	[−3.240]	[16.965]	[3.209]	[−2.712]	[1.639]		
(3) 1861-1913	−0.038	0.458	0.048	−0.009	0.019	0.738	2.528
	(−2.869)	(3.937)	(3.253)	(−0.708)	(0.387)		
	[−1.513]	[2.335]	[1.746]	[−0.342]	[0.762]		
(4) 1861-1938	−0.044	0.838	0.043	−0.069	−0.122	0.900	0.999
	(−2.619)	(19.169)	(2.488)	(−3.105)	(−1.570)		
	[−1.875]	[15.246]	[1.956]	[−2.359]	[−1.759]		
(5) 1861-1990	−0.015	0.873	0.011	−0.094	0.015	0.897	1.172
	(−2.170)	(26.488)	(1.431)	(−5.022)	(0.331)		
	[−1.937]	[17.752]	[1.244]	[−3.318]	[0.202]		
(6) 1861-1990	−0.019	0.792	0.020	−0.057	0.049	0.866	1.848
excl. 14-19, 39-47	(−3.607)	(22.094)	(3.326)	(−3.481)	(0.837)		
	[−2.816]	[16.684]	[2.685]	[−2.349]	[1.134]		
(7) 1948-2009	−0.018	0.825	0.019	−0.194	0.388	0.845	1.772
	(−2.780)	(14.602)	(2.369)	(−4.919)	(3.010)		
	[−2.681]	[16.882]	[2.556]	[−5.407]	[4.408]		

Notes: OLS estimates with annual data; ( ) = ordinary t-statistics; [ ] = robust t-statistics, computed using the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix with lag truncation $q = \text{floor}\left(4\left(\mathrm{T}/100\right)^{\frac{2}{9}}\right)$, where T is the number of observations; DW = Durbin-Watson statistic.

Table 7: Regression results for the primary surplus-GDP ratio, using $GVAR_t$ and $YVAR_t$, and in the presence of inertia.

Equation for s_t							
Sample	Const.	s_{t-1}	b_{t-1}	$GVAR_t$	$YVAR_t$	R^2	DW
(1) 1861-2009	−0.021	0.825	0.019	−0.569	−0.470	0.900	1.082
	(−3.270)	(25.424)	(2.634)	(−6.987)	(−3.475)		
	[−2.703]	[16.393]	[2.154]	[−4.374]	[−2.080]		
(2) 1861-2009	−0.023	0.760	0.024	−0.405	−0.548	0.862	1.700
excl. 14-19, 39-47	(−4.404)	(22.086)	(4.182)	(−5.059)	(−1.944)		
	[−3.260]	[16.085]	[3.196]	[−2.956]	[−1.806]		
(3) 1861-1913	−0.037	0.455	0.047	−0.029	−0.192	0.737	2.563
	(−2.787)	(3.905)	(3.190)	(−0.375)	(−0.529)		
	[−1.469]	[2.330]	[1.714]	[−0.227]	[−1.027]		
(4) 1861-1938	−0.042	0.816	0.041	−0.356	0.667	0.905	1.014
	(−2.552)	(17.855)	(2.422)	(−3.088)	(1.661)		
	[−2.008]	[14.278]	[2.103]	[−2.138]	[1.713]		
(5) 1861-1990	−0.019	0.838	0.016	−0.538	−0.410	0.902	1.040
	(−2.826)	(24.387)	(2.046)	(−6.148)	(−2.872)		
	[−2.319]	[15.547]	[1.632]	[−3.844]	[−1.683]		
(6) 1861-1990	−0.020	0.786	0.021	−0.357	−0.317	0.872	1.728
excl. 14-19, 39-47	(−3.824)	(22.116)	(3.493)	(−4.128)	(−1.044)		
	[−2.811]	[16.210]	[2.649]	[−2.328]	[−1.119]		
(7) 1948-2009	−0.019	0.806	0.020	−0.727	−1.424	0.846	1.680
	(−2.943)	(14.336)	(2.522)	(−4.943)	(−2.916)		
	[−2.819]	[15.815]	[2.746]	[−5.899]	[−3.915]		

Notes: OLS estimates with annual data; ( ) = ordinary t-statistics; [ ] = robust t-statistics, computed using the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix with lag truncation $q = \text{floor}\left(4\left(\text{T}/100\right)^{\frac{2}{9}}\right)$, where T is the number of observations; DW = Durbin-Watson statistic.